Analysis of

RESTORATION OF LIGHT RAIL TO THE ARBORWAY

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1. INTRODUCTION

This report analyzes the issues associated with the restoration of light rail transit (LRT) service in the Arborway corridor from Heath Street to Forest Hills Station along South Huntington Avenue, Centre and South Streets. Major study tasks included a field inventory and analysis of existing conditions, a survey of transit trends and experience, a review of design guidelines, the development of a proposed conceptual design and the analysis of impacts associated with the proposed restoration. Based in part on the findings of this and other reports, the Executive Office of Transportation and Construction (EOTC) will make a determination of feasibility for submission to DEP.

The corridor features a built-up urban environment and relatively narrow streets that are used by cars, trucks, buses, pedestrians, bicyclists, residents, businesses and visitors. Recognizing the established physical features of the corridor, there is insufficient public rights-of-way for the construction of an exclusive or semi-exclusive LRT alignment without the elimination of on-street parking along both sides of the street for the total length of the corridor. Therefore it was assumed that the proposed LRT system would operate in mixed traffic and share the travel lane with other vehicles.

1.1. Background

Light rail service was previously provided to the Forest Hills station as part of the Massachusetts Bay Transportation Authority's (MBTA's) "E" branch of the Green Line. This service was suspended in December 1985, to facilitate the reconstruction of Huntington Avenue. Light rail service was subsequently restored to Brigham Circle and eventually to Heath Street and the South Huntington Avenue turn around loop. South of the current "E" Branch terminus at Heath Street, the remainder of the Arborway corridor is served by the Route 39 Bus which runs from Forest Hills station to Back Bay Station, while the MBTA evaluates future transit improvements to the corridor. The Arborway Restoration Project is part of transit improvements required by 310 CMR 7.36 relating to air quality. This regulation, which is administered through the Massachusetts Department of Environmental Protection (DEP), requires that the Executive Office of Transportation and Construction (EOTC) "plan, construct, render available for public use certain transportation improvements in accordance with a specified schedule."

In January 1999, EOTC updated DEP on the status of the Arborway Restoration Project, and submitted to DEP a petition for a substitute project that is allowed under 310 CMR 7.36. DEP responded to that submission in a September 1, 2000 letter stating that DEP… "finds that EOTC has not yet demonstrated that it is infeasible to restore light rail to the Arborway corridor. The transit regulation requires that EOTC demonstrate that the specific project listed in 310 CMR 7.36 is infeasible due to associated engineering, economic or environmental impacts".

This study is a partial response to the DEP directive. The study analyzes design and construction (i.e, "engineering") issues and cost (i.e. "economic") issues. Other issues analyzed here, such as loss of parking and traffic congestion can be seen as both environmental and economic. Environmental issues related to ridership, reduction in automobile vehicle miles travelled and pollution produced by transit vehicles are addressed in other studies.

2. EXISTING CONDITIONS

The Arborway corridor includes Huntington Avenue, South Huntington Avenue, Centre Street and South Street to Forest Hills station. The MBTA operates Green Line "E" Branch service on Huntington Avenue and South Huntington Avenue to Heath Street. The LRT service operates in a tunnel as part of the central subway. The "E" Branch service has a portal on Huntington Avenue at Northeastern University, operates in its own reservation to Brigham Circle and operates in mixed traffic between Brigham Circle and Heath Street.

In 1985, the MBTA suspended “E” Branch service between Heath Street and Forest Hills. The MBTA operates frequent service on the Route 39 bus from Forest Hills to Back Bay station as a replacement service for the “E” Branch south of Heath Street. Four other bus routes operate in the corridor, including: Route 37, Route 38, Route 41 and Route 48.

This section of the report documents existing physical and transit conditions that were inventoried in December 2000 and January 2001. For this study, the corridor under evaluation includes:

- **South Huntington Avenue** - Heath Street to Centre Street;
- **Centre Street** - South Huntington Avenue to South Street; and
- **South Street** - Centre Street to Forest Hills station

The physical features of this corridor were inventoried for evaluation of the restoration of LRT service from Heath Street to Forest Hills.

2.1. Physical Features

The Arborway corridor is composed of two-way undivided streets (i.e., there is no center median) in its entirety. In general, the primary functions of the corridor are to provide access to and from nearby origins and destinations and serve as a collector-distributor roadway with connections to radial arterials such as the Jamaicaway. The streets also provide parking for adjacent land uses and are particularly active during the middle of the day. This coincides with activity related to the commercial districts on Centre Street and South Street, and institutional uses, such as the Curley Middle School. The following sections provide additional information about the physical attributes of the corridor, which is shown in Figure 1.

2.1.1. Roadway

The three segments of the Arborway corridor, (South Huntington Avenue, Centre St. and South St.) have different physical roadway characteristics. Along each of the segments, multiple measurements were made at selected mid-block locations to determine sidewalk and roadway width.

On South Huntington Avenue, measurements were made at: Riverway station; Goddard House; between Evergreen and Bynner Streets; and between Perkins and Barbara Streets. The Avenue is approximately 54 foot wide from curb to curb including 8-foot parking lanes which are located along both sides of the street. Two-way traffic uses the remaining 38 feet of roadway with two travel lanes in each direction. Eight-foot sidewalks are located along both sides. By comparison, Huntington Avenue, east of South Huntington Avenue, which currently accommodates LRT in mixed traffic is wider still, with a curb to curb roadway width of approximately 60 feet measured at the Mission Park Green Line stop.

On Centre Street, mid-block measurements were made between Kingsboro and Spring Park, and between Harris Ave. and the fire station. The approximately 42-foot curb to curb width includes 8-foot parking lanes along both sides of the street and one wide travel lane in each direction. Eight-foot sidewalks are located along both sides.

A series of mid-block measurements on South Street at Boynton, Hall and St. Rose Streets indicate a slightly narrower roadway width of approximately 40 feet curb to curb. The roadway width includes 8-foot wide parking lanes along both sides of the street and one travel lane in each direction. Eight-foot sidewalks are located along both sides of the street.

Restoration of Light Rail to the Arborway

Location Map
Arborway Corridor

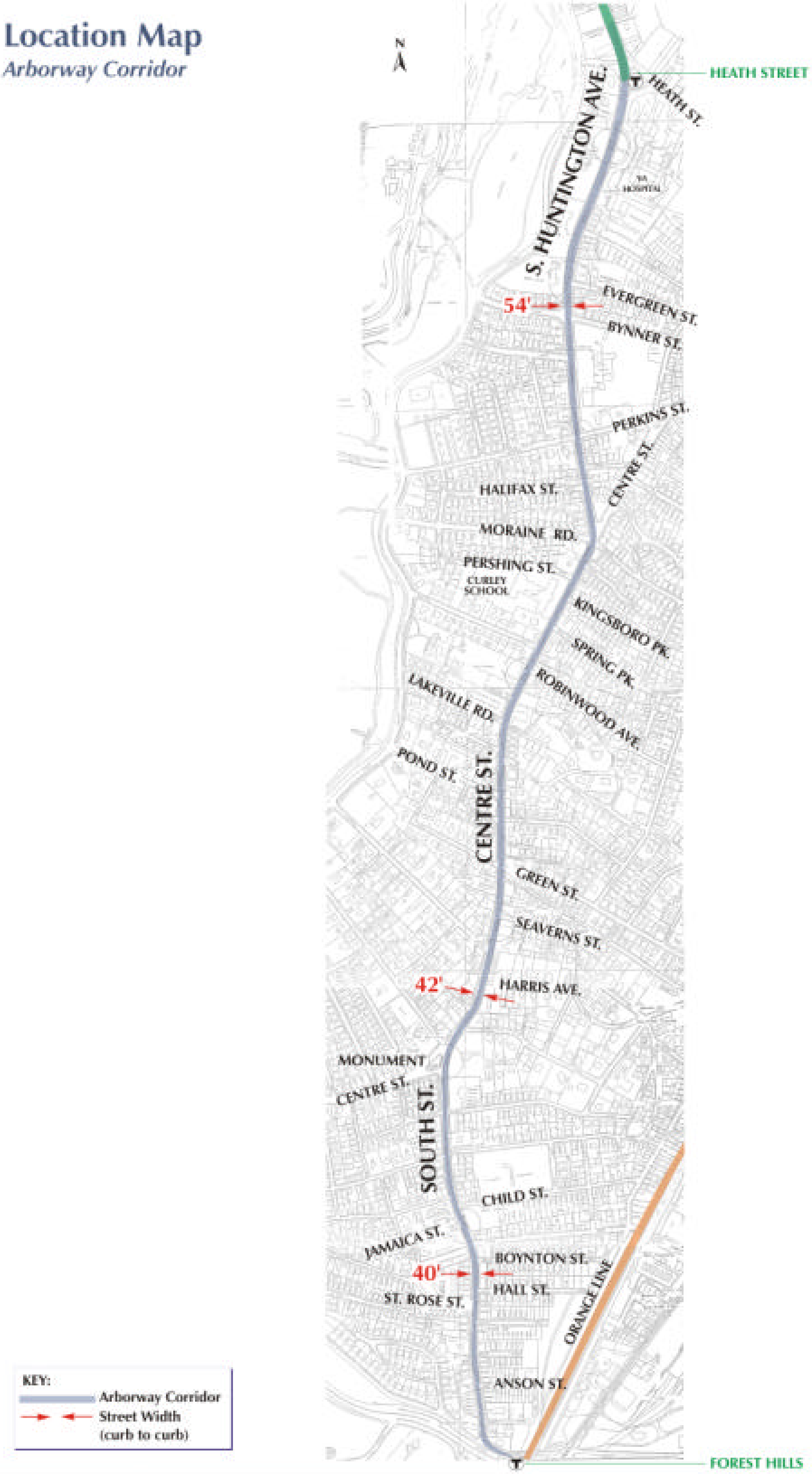


Figure 1

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Between September and November 2000, South Huntington Avenue was repaved and the tracks were covered. As a result of this work, the roadway surface is in excellent condition. The rails from the discontinued service remain on the surface of the Centre Street and South Street where pavement quality is adequate and some areas require maintenance. Pedestrian actuated signals are located at major intersections and at the eleven traffic signals in the corridor. Some of the signals use newer equipment and are fully or partially actuated.

Traffic signals are located at the following intersections in the corridor:

- South Huntington Avenue/VA Hospital (Pedestrian Signal)
- South Huntington Avenue/Bynner Street
- South Huntington Avenue/Perkins Street
- South Huntington Avenue/Centre Street/Boylston Avenue
- Centre Street/Green Street
- Centre Street/Thomas Street
- Centre Street/South Street/Elliot Street (Pedestrian Signal)
- South Street/Carolina Avenue
- South Street/Child Street
- South Street/McBride Street
- South Street/Arborway

2.1.2. Land Use

Figure 2 illustrates existing land use along the corridor. The scale and mix of residential, small retail, office and neighborhood institutional uses reflect distinct development patterns in the area and help to define the character of the corridor along South Huntington Avenue, Centre Street and South Street.

Residential

Residential land uses are located throughout the corridor. The highest concentration occurs on South Huntington Avenue, South Street and on the side streets adjacent to the corridor. The housing stock is primarily detached two-and three story homes, although there are several multi-story apartment buildings on or near the corridor. Many residential units rely upon on-street parking or driveways while several larger apartment buildings feature off-street lots.

Retail

Neighborhood-scale retail stores are concentrated on Centre Street between Green and Elliot Street. These businesses, which include restaurants, small clothing stores, food markets and specialty stores, are located in one story buildings or in the first floor of two- and three-story buildings. While some retail businesses have off-street parking and loading facilities adequate to meet demand, most rely on on-street parking and loading and, when available and nearby, off-street municipal parking lots.

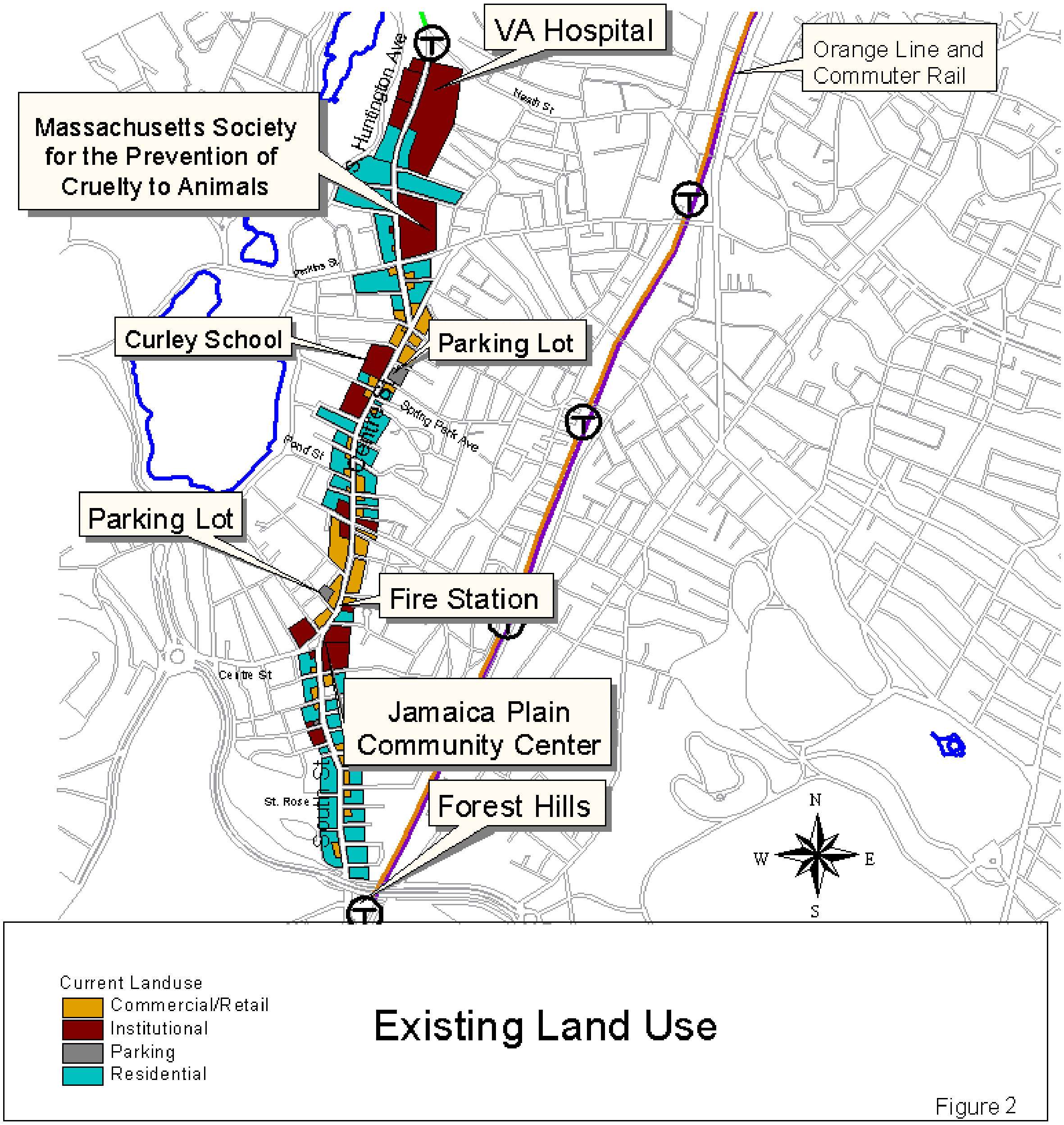
Office

Small professional offices such as attorneys and real estate agencies are located along the corridor. Most businesses rely on on-street parking and, when available and nearby, off-street municipal parking. Loading needs are less intensive for these types of businesses.

Public Facilities

Neighborhood public facilities are also located in the corridor, including a branch of the Boston Public Library, the Curley Middle School and the Boston Fire Department. A second branch of the library and the Agassiz School are located within a block of the corridor.

Restoration of Light Rail to the Arborway



Existing Land Use

Figure 2

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Institutions

Large institutional land uses are primarily located on South Huntington Avenue. These include the Veteran Administration Hospital and the Massachusetts Society for the Prevention of Cruelty to Animals. Both facilities provide off-street parking and loading facilities.

Funeral Homes

There are two funeral homes on the corridor. These businesses are typically busy in the evening and weekends when they generate demand for on-street parking.

2.1.3. Parking

Parking supply was inventoried along with existing parking regulations and the number of spaces on the corridor from Heath Street to Arborway. On-street parking is currently available along the length of the corridor and most of the supply is unregulated (i.e., there is no time limit other than street cleaning or snow emergency restrictions) with short-term parking available in the commercial districts. The Boston Transportation Department (BTD) has posted 2-hour parking limits on both sides of Centre Street between Green Street and South Street, which includes most of the retail and commercial activity for corridor, and along the eastern side of South Street between McBride Street and Hall Street. The purpose of this regulation is to encourage “turnover” (i.e., the use of each space by multiple vehicles throughout the day).

Parking stalls were not delineated or striped along the street and the number of parking spaces were estimated by assuming that an average parking space is 20 feet long, which is typical of lengths used for parking meters, and then verifying this approach through field observations. As noted in Table 1, there are approximately 615 on-street parking spaces along the corridor: approximately 225 spaces on South Huntington Avenue between Heath Street and Centre Street; approximately 215 on Centre Street between South Huntington Ave. and South St; and approximately 175 on South St. between Centre Street and Arborway.

The number of vehicles parked in the study area were inventoried to determine the utilization characteristics of the corridor (i.e., the number of spaces occupied by parked vehicles). In general, 85 percent occupancy represents the practical capacity of a parking area. At occupancy levels below 85 percent, motorists can typically find a parking space within reasonable walking distance of their destination. At occupancies of 85-percent or greater, motorists may have to park further from their destination than would otherwise be desirable. This can result in motorists circling the block to look for a parking space or an increased occurrence of double parking. Table 1 summarizes the average utilization of the existing on-street parking supply for three time periods: AM (7:00 to 9:00 AM), Midday (11:00 to 2:00 PM) and PM (4:00 to 6:00 PM).

Table 1 – On-street Parking Accumulation[1]

		Percent Occupied		
Segment	**Number of Spaces**	**AM** (7 – 9 AM)	**Midday** (11 – 2 PM)	**PM** (4 – 6 PM)
South Huntington Avenue (Heath St. to South St.)	225	55%	68%	40%
Centre Street (S. Huntington St. to South St.)	215	77%	84%	66%
South Street (Centre St. to Washington St.)	175	73%	73%	63%
TOTAL	**615**	**69%**	**75%**	**58%**

Notes: 1. Survey conducted on December 12-13, 2000.

The percent of occupied spaces along the corridor varies by time of day and location. Parking utilization along the corridor was heaviest during the midday hours between 11 AM and 2 PM with a total corridor utilization of 75 percent. The midday period is also the peak period for parking utilization for each section of the corridor. Centre Street has the highest utilization of parking, approaching the practical capacity of 85 percent during the midday, reflecting the commercial nature of this segment of the corridor. Neighborhood retail businesses typically open after 10:00 AM and are busy during the middle of the day. The availability of parking on South Street is comparable to Centre Street. However, the demand for parking on this street includes all-day parking by residents. On one section of South Street between Arborway and Child Street, parking demand is at or near 100 percent, well above the level of practical capacity. In contrast, South Huntington Avenue has excess capacity throughout the day due to the availability of off-street parking at the large institutions. General observations indicate that side streets along the Arborway Corridor exhibit the same parking characteristics, including the same high levels of parking occupancy, as the main street they cross (South Huntington Avenue, Centre Street, or South Street).

The two municipal off-street parking lots located along Centre Street also provide parking spaces for the corridor. One lot is across from Curley Middle School and the other is located in the commercial district of Jamaica Plain adjacent to Thomas Street. The lot near the Curley School holds 23 vehicles and is heavily utilized while the Thomas Street lot holds 103 vehicles and is moderately utilized (i.e., excess capacity was observed during the survey).

2.1.4. Travel Time

Travel time data was collected in the corridor during the AM, midday and PM periods. Trip times were determined by recording the starting time that a vehicle departed a control point at each end of the corridor and when passing other control points in the corridor. This data was used to calculate average travel time for the entire corridor and each of the three segments. The data was compiled for both inbound trips (originating at Forest Hills station and ending at Heath Street station) and outbound trips (originating at Heath Street station and ending at Forest Hills station).

Table 2 presents the average auto travel times for the different segments of the corridor. In general inbound and outbound average travel times were comparable except during the peak direction of the peak commuting hours. Average inbound trip times from Arborway to Heath Street during the AM peak period were almost 10 minutes as compared to 7-8 minutes during the midday and PM peak periods. A similar pattern was true for outbound trips from Heath Street to Arborway: the PM peak period average trips times were almost 10 minutes as compared to 7-8 minutes during the AM peak and midday periods.

Table 2 – Average Auto Travel Times

		North/Inbound[1] (Minutes)			**South/Outbound[2] (Minutes)**		
Segment	**Distance**	**AM**	**Midday**	**PM**	**AM**	**Midday**	**PM**
South Huntington Avenue **(**Heath St. to South St.)	0.6 miles	2.0	1.7	1.9	2.1	2.5	2.6
Centre Street (S. Huntington St. to South St.)	0.7 miles	4.8	3.6	3.7	2.7	3.4	3.8
South Street (Centre St. to Arborway)	0.6 miles	3.2	2.0	2.2	2.3	2.4	3.5
TOTAL[3]	1.9 miles	10.0	7.3	7.8	7.0	8.1	9.8

Notes:
1. Forest Hills to Heath Street
2. Heath Street to Forest Hills
3. May be less than or greater than sum of sections due to rounding.

While nearly as long as either Centre or South Street, South Huntington Avenue had the shortest travel times and least congestion of the three segments since it is the widest and has the greatest capacity.

Inbound vehicles took twice as long to travel Centre Street than South Huntington Avenue, even though both streets are approximately the same length. The difference was significant though less pronounced in the outbound direction. South Street travel times were comparable to those of South Huntington Avenue except for the AM inbound direction and the PM outbound direction. The South Street travel times and the higher travel times on Centre Street resulted in overall higher average travel times in the inbound direction during the AM peak period and in the outbound direction during the PM peak period.

Key factors influencing travel time are the differences in traffic volumes, intersection delay and the other operating characteristics of Centre Street and South Street that are described below. Similar results for travel times were found in the 1987 TAMS study, which also referenced the congestion impacts of the commercial and retail activities on Centre Street.

2.1.5. Traffic Observations

Field observations were noted throughout the corridor and daily traffic volume data was collected at four locations. As noted in Figure 3, several locations in the corridor experienced traffic congestion related to: traffic volumes; shopping and deliveries in the commercial and retail business districts; signalized intersection operation; activity around the Curley Middle School; and emergency vehicle operations at the fire station.

Traffic Volumes

Daily traffic volume data was collected at four locations by 15 minute intervals over a 48 hour period on January 3 and 4, 2001. The highest daily traffic volumes occurred on Centre Street where 17,900 vehicles were recorded during a 24 hour period. By comparison, there were 13,000 vehicles recorded on South Huntington Avenue and 12,100 vehicles recorded on South Street over a 24 hour period. The range in volumes reflect the different land use and traffic functions of each street. Traffic flows converge on Centre Street, which connects Columbus Avenue and the Jamaicaway, but also provides access to and from South Huntington Avenue and Forest Hills via South Street. As a result, volumes are highest on this section of the corridor.

Table 3 presents the peak hour traffic volumes at four locations along the corridor. This data supports the previous observation that the corridor is a multi-use route that experiences a substantial level of activity throughout the day. A typical commuter route experiences peak demand during the traditional peak periods of 7-9 AM and 4-6 PM and has a uniformly higher flow in one direction. The peak times of the streets in corridor vary at the four locations that were counted. Traffic flow has a pronounced inbound flow early in the morning on South Huntington Avenue and an outbound flow on Centre Street just before the PM peak hour. Hourly volumes approached a near 50-50 split in directional volume on South Street and Centre Street in the AM peak hour.

Table 3 – Weekday Peak Hour Traffic Volumes

	AM Peak Hour Volumes				**PM Peak Hour Volumes**			
Street	**Hour**	**North[1]**	**South[2]**	**Total**	**Hour**	**North[1]**	**South[2]**	**Total**
South Huntington Avenue (South of Bynner Street)	6:15 –7:15 AM	849	184	1033	5-6 PM	445	472	917
Centre Street (North of Robinwood Avenue)	8:30 – 9:30 AM	524	555	1079	2:45 – 3:45 PM	569	716	1285
Centre Street (North of Harris Street)	8:15-9:15 AM	605	454	1059	5 –6 PM	524	632	1156
South Street (North of McBride Street)	8:45 – 9:45 AM	351	428	779	5-6 PM	419	428	847

Notes:
1. Forest Hills to Heath Street
2. Heath Street to Forest Hills.

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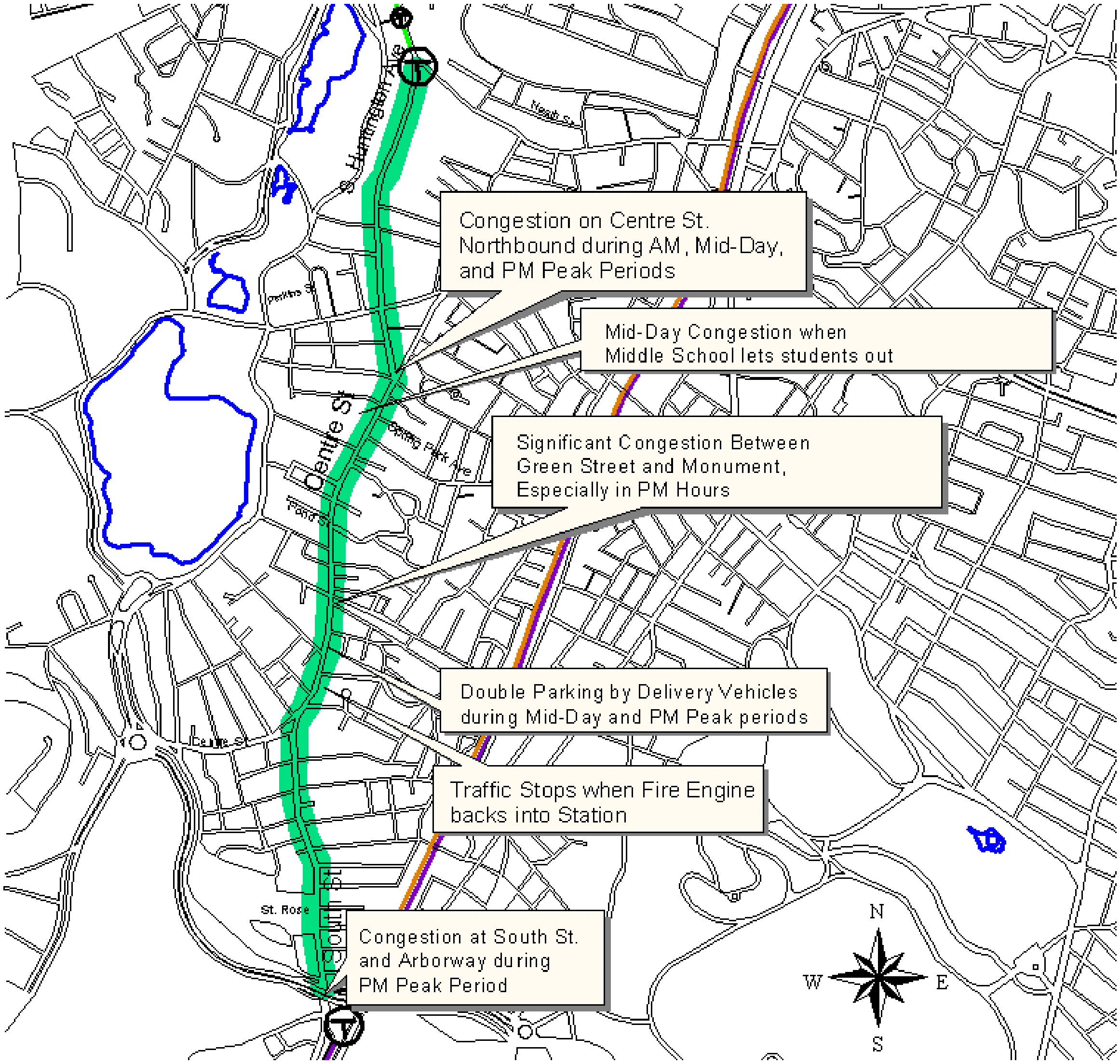

Congestion on Centre St. Northbound during AM, Mid-Day, and PM Peak Periods

Mid-Day Congestion when Middle School lets students out

Significant Congestion Between Green Street and Monument, Especially in PM Hours

Double Parking by Delivery Vehicles during Mid-Day and PM Peak periods

Traffic Stops when Fire Engine backs into Station

Congestion at South St. and Arborway during PM Peak Period

Traffic Issues
in Arborway Corridor

Figure 3

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

These results reflect the trip generation characteristics of land uses along the corridor, particularly the neighborhood residential and retail activities. Other factors include traffic generated by nearby locations such as hospitals with shift changes that generate work trips before the typical commuting peak hours. The proximity of the corridor to major radial roadways such as the Jamaicaway, Huntington Avenue, Tremont Street and Washington Street and cross-town connections such as the Arborway also contribute to the traffic volume on the corridor.

Commercial Activity

Vehicular activity in the commercial and retail sections of the corridor contributes to traffic operation issues including: parking maneuvers into and out of on-street spaces; curb side deliveries; double parking; and pedestrian activity. These issues are common in neighborhood commercial districts with active pedestrian areas and that rely on curb parking and loading access.

The curb to curb width of Centre Street and South Street exacerbate operational issues noted above because of the narrow roadway and narrower travel lanes. Parking maneuvers into and out of on-street spaces require upstream vehicles to wait until the maneuver is completed or to cross the double-yellow line and pass the maneuvering vehicle. Similar issues occur when trucks back into or pull out of curb spaces. Double parking also contributes toward congestion on Centre and South Streets by blocking the single travel lane. Contributing factors include the limited number of loading zones along the corridor and the desire of some motorists to park as close to their destinations as possible despite the general availability of parking on a corridor-wide basis.

Intersection Operations

Field observations were used to identify and review intersection operations along the corridor with congestion and delays noted at two signalized intersections and at several unsignalized intersections within the commercial district. A formal intersection Level of Service analysis was not conducted as part of this study.

Congestion problems were identified at the South Huntington Avenue, Centre Street and Boylston Street intersection. The northbound approach (on Centre Street) to the intersection experienced delays during the day with queues up to 300 feet long observed. The operational issues occur because of the limited roadway cross section at the intersection: each approach has one lane and the intersection operates on three phases. The northbound approach does not have sufficient capacity to accommodate the Center Street volumes.

The South Street and Arborway signalized intersection experiences congestion on the southbound South Street approach during the PM peak period. This congestion appears to be related to the complexity of traffic patterns and general traffic volumes in and around Forest Hills.

Due to the presence of only a single travel lane in each direction on Centre and South Streets, left turning vehicles block the normal flow of through traffic at unsignalized intersections. A vehicle must wait for an appropriate gap in the opposing traffic stream in order to complete the turn. Vehicles behind the one that is turning queue-up until the turning vehicle clears the intersection.

Curley School

During the morning and midday periods, congestion was observed on Centre Street at the Curley Middle School prior to and immediately after the end of the school day as the result of parents dropping off and then picking up children. High levels of pedestrian activity also occur here, including a significant volume of pedestrian crossings that occur outside the designated crosswalk locations.

Fire Station

When responding to an emergency, a traffic signal in front of the fire station stops traffic so the emergency vehicles can exit the station. Due to the layout and orientation of the fire station on Centre

Street, traffic on the street is halted for a longer period of time when emergency vehicles return and maneuver back into their bays.

Bus Operations

MBTA bus activity did not appear to contribute significantly to the congestion problems in the corridor. Observations indicate a high level of compliance with the No Parking regulation at the bus stops with most buses pulled to the curb to pick-up and discharge passengers, thereby allowing other vehicles to pass. Minor delays were noted when buses were unable to or failed to pull to the curb, a relatively minor contributing factor to corridor-wide congestion.

2.1.6. Pedestrians

Frequent pedestrian activity in the Arborway corridor was observed as the land use and street geometry are conducive towards pedestrian movements. Pedestrian activity is spread along the length of the corridor with centers of activity located around the intersection of Centre Street and South Huntington Avenue, the Curley School, the Jamaica Plain commercial district and along South Street. Numerous cross walks were noted as sidewalks are present along the length of the street with business, commercial, institutional and residential land uses fronting the sidewalk. Pedestrians were observed crossing the corridor at unmarked locations, thereby creating a “dart-out” condition. This dart-out condition arises when a pedestrian emerges from between two parked cars or other unmarked crossing location and attempts to cross an active street. They are a frequent source of pedestrian related automobile crashes.

2.1.7. Bicyclists

Bicycle activity is common in the Arborway corridor for many of the same reasons pedestrian activity is prevalent. Bicyclists were observed typically riding on the street between the parked vehicles and the moving traffic. Bicyclist activity peaks in periods of good weather when cycling conditions are easier and additional cyclists are traveling to the neighboring Emerald Necklace parks. Significant bicycle activity were observed around the Curley School, the Jamaica Plain commercial district, and along South Street with cyclists accessing the Orange Line at Forest Hills station.

2.1.8. Motor Vehicle and Transit Accident Experience

Accident experience was obtained for motor vehicles accidents (crashes) in the Arborway corridor and for transit accident experience both in Boston and at selected transit systems in North America with similar operating characteristics.

Motor Vehicle Crash Experience

During the three-year period between 1995 and 1997 there were 140 recorded vehicular crashes along the Arborway Corridor encompassing: all of South Huntington Avenue; Centre Street between South Huntington Avenue and South Street; and South Street between Centre Street and Washington Street.

Based upon the crash data obtained from the Massachusetts Highway Department, most occurred along Centre Street, with 75 percent of the Centre Street crashes concentrated between Pond Street and South Street. This segment is the center of commercial activity in Jamaica Plain and is characterized by small blocks, obstructed views, and frequent parking activity, all which contribute to the high number of crashes in the area. Three of the most crash prone intersections along the Pond Street and South Street segment (accounted for over 40 percent of all crashes along Centre Street) include: Centre Street/South Street, Centre Street/Green Street, and Centre Street/Pond Street.

The other high crash intersection along the corridor is the intersection of South Street and Washington Street accounting for over 90% of the crashes along South Street during the three-year period. Table 4 summarizes crash data for the corridor and the four intersections discussed above.

Table 4 – Motor Vehicle Crash Summary for Arborway Corridor

Street/Intersections[1]	1995	1996	1997	Total (1995-1997)	Number of Injury Crashes
Street Segments					
South Huntington Avenue	11	12	11	34	14
Centre Street	29	23	28	80	31
South Street	5	9	12	26	12
Intersections					
Centre St/Green St Intersection	3	2	2	7	0
Centre St/Pond St Intersection	5	2	3	10	4
Centre St/South St Intersection	5	7	5	17	8
South St/ Washington St Intersection	5	9	10	24	9

Note 1. Intersection accidents are not included in street segment totals.

Transit Accident Experience

An analysis of motor vehicle/pedestrian/transit accident experience in Boston and selected transit systems in North America with similar operating characteristics was obtained[1] to provide a basis of comparison to other transit systems. The accident experience indicates that while transit accidents occur less frequently than motor vehicle accidents, a disproportionate share of transit accidents occur when the transit vehicle operates in a shared (non-exclusive, i.e. “street running operation”) rights-of-way with motor vehicles, even though this type of alignment generally constitutes the smallest proportion of route miles. Far fewer motor vehicle/pedestrian/transit accidents occur on semi-exclusive or exclusive rights-of-way since their design limits (semi-exclusive) or precludes (exclusive) potential conflicts between motor vehicles/pedestrians and transit vehicles.

As shown in Table 5, 100 percent of the motor vehicles/pedestrian/transit accidents in Boston occurred in shared rights-of-way, which accounted for only 32 percent of mainline track miles as compared to semi-exclusive or exclusive rights-of-way which constitute the remaining 68 percent of mainline track miles. A safety index, which enables direct comparisons between systems, uses average annual accidents per mainline track mile per year within shared rights-of-way at low to moderate speeds. In the safety index column, where a lower value indicates lower accident experience, Boston exhibited the highest accident experience. These relatively high accident rates were attributed to poor street geometry and transit alignment characteristics.

Table 5 – Transit Accident Trends in Shared Rights-of-Way Under 35 MPH

Light Rail Transit System	Percentage of Total Accidents(1) in Shared(2) Rights-of-Way	Percentage of Mainline Track Miles in Shared(2) Rights-of-Way	Safety Index (Ave. number of accidents per track mile per year)
Baltimore	89	18	5.9
Boston	100	32	6.2
Buffalo	100	20	0.5
Calgary	71	7	6.1
Los Angles	79	23	4.6
Portland	90	52	1.5
Sacramento	85	26	2.5
San Diego	75	11	2.9
San Francisco	100	70	4.5
San Jose	98	44	1.6
All Systems	92	31	3.7

1 Accidents involving a motor vehicle or pedestrian and a LRV.
2 Non-exclusive ROW (i.e. “street running” operation)

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[1] Integration of Light Rail Transit into City Streets, TCRP Report 17, Transportation Research Board, 1996.

2.2. Previous Transit Service

A description of the previous transit service in the corridor was reviewed and the following main points noted.

2.2.1. Description of Service

The Green Line's "E" Branch provided Arborway light rail transit service that connected Forest Hills station and Park Street station in Downtown Boston. This service, which featured Presidential Conference Cars (PCC's) was suspended in 1985 to facilitate the reconstruction of Huntington Avenue. The PCC's, which were 35 to 40 years old at the time and the oldest revenue vehicle in the MBTA's fleet, operated in two-car train sets between Park Street and Forest Hills, at 6 minute headways during peak periods.

The PCC's operated in mixed traffic (street running) in the Arborway corridor with the track located in the center of the roadway and passengers loading and unloading in the street. Traction power for the cars was provided by an overhead contact system (OCS) which remains in place today along much of the corridor. The line served 50,000 weekday and 15.3 million annual riders in 1985.

Service disruptions on the southern portion of the Arborway line were "common", resulting from interference with traffic, pedestrians and breakdowns due to the advanced age and subsequent deteriorating condition of the PCC fleet.[2]

2.3. Existing Transit Service

In the immediate vicinity of the Arborway corridor, transit service is provided by several bus routes and the Orange Line. As illustrated in Figure 4, multiple MBTA bus routes converge and overlap on Centre Street and South Street. In addition, Orange Line stations at Forest Hills and Green Street are located within close proximity to South Street and parts of Centre Street.

The 1987 TAMS[3] report and the 1999 LS Transit Systems[4] report for the MBTA contained information regarding travel behavior in the corridor. The 1987 report surveyed passengers on the Route 39 bus and found that 60 percent of riders resided in Jamaica Plain and that trips along the corridor were frequently of a short duration, i.e. less than 10 minutes. The 1999 report found that 70 percent of riders lived within a 5 minute walk of their bus stop and that in addition to high levels of peak period usage, substantial midday usage all occurred. Both reports found a higher than metro-average transit dependant population and these observations indicate that the corridor serves a variety of trip types (commute to/from work, social visits, shopping, recreational, etc.) throughout the day.

2.3.1. Existing MBTA Bus Service

The MBTA currently operates frequent service (headways less than 10 minutes) on the Route 39 from Forest Hills to Back Bay station. The Route 39 has a free transfer from the subway system in the outbound direction and a $0.25 transfer inbound to the subway system, making the inbound route the same charge as a subway ride. The MBTA operates four other bus routes on the corridor as described below and illustrated in Figure 4.

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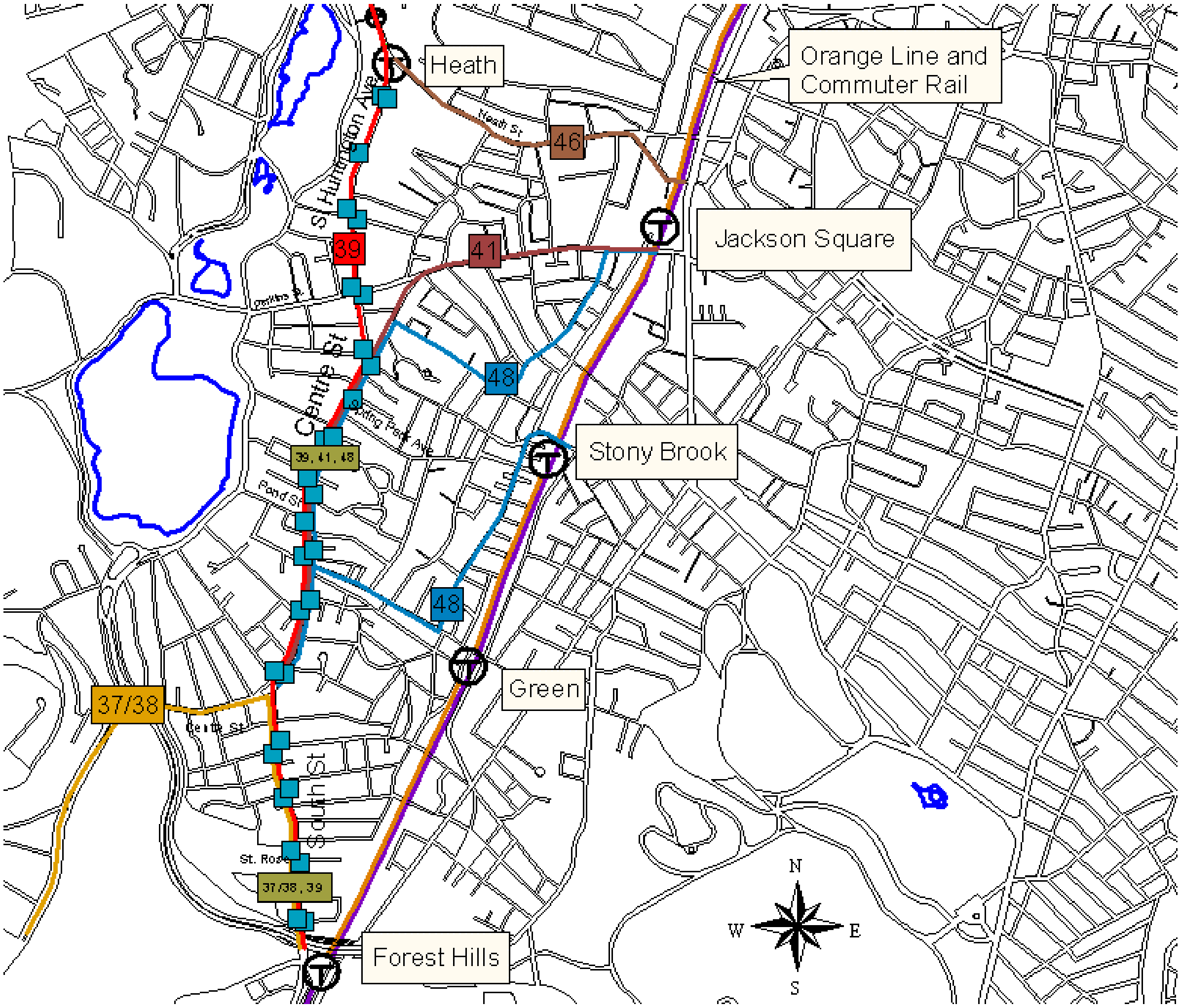
[2] Massachusetts Bay Transportation Authority, *DRAFT Arborway Transit Study*, TAMS et al, December 1987.

[3] Ibid.

[4] Massachusetts Bay Transportation Authority, *The Arborway Study – Final Report*, LS Transit Systems, January 1999.

Restoration of Light Rail to the Arborway



🟦 Existing Bus Stops

Existing Bus Routes and Bus Stops

Figure 4

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

The Route 39 bus travels the length of the corridor as part of its route between Back Bay station and Forest Hills station. Four other bus routes operate on the corridor. Routes 38 (Wren Street-Forest Hills Station) and Route 37/38 Sundays (Baker & Vermont Street – Forest Hills Station) parallel the corridor along South Street between Arborway and Monument. Routes 41 (Centre & Eliot Streets – Dudley Station) and 48 (Jamaica Plain Loop) parallel the corridor along Centre Street between Monument and South Huntington Avenue.

2.3.2. Bus Stop Locations

As illustrated in Figure 4, there are 29 bus stops located throughout the corridor, 14 inbound and 15 outbound, located at 400 to 600 foot intervals, representing a 2-3 minute walk from any location on the corridor to a bus stop. The length of bus stops varies by location and the number of routes that are using the stops. Smaller stops are 35 feet long and are typically located at intersections or near hydrants. The longest stop is 105 feet long and accommodates multiple bus routes.

2.3.3. Bus Headways

The MBTA operates frequent service on the Route 39 with Routes 38, 41 and 48 operating less frequently and the Route 37 only available on Sundays. The Route 39 also has the longest hours of operation while service on the Route 48 is oriented toward midday hours. Saturday and Sunday service is less than weekday service. Table 6 summarizes the hours of service and the headways for each route.

Table 6 – Service Hours and Headways for Current Bus Routes on the Arborway Corridor[1]

		Weekday		Saturday		Sunday	
Rte	**Description**	**Service**	**Headway**	**Service**	**Headway**	**Service**	**Headway**
37	Baker & Vermont St – Forest Hills Station	No Service	No Service	No Service	No Service	9:15 AM – 6:15 PM	60 min
38	Wren Street-Forest Hills Station	5:47 AM – 11:13 PM	20-40 min	5:30 AM – 10:40 PM	40 min	9:15 AM – 6:15 PM	60 min
39	Forest Hills Sta. – Back Bay Sta. via Huntington Ave	4:42 AM – 12:32 AM	Less than 10 min	4:42 AM – 12:30 AM	Less than 10 min	5:30 AM – 12:30 AM	12 min
41	Centre & Eliot Streets – Dudley Station	5:10 AM – 8:15 PM	20-30 min	7:43 AM – 7:10 PM	40 min	No service	No Service
48	Jamaica Plain Loop	9:00 AM – 4:30 PM	30 min	9:00 AM – 4:30 PM	35 min	No Service	No Service

1. Heath Street to Forrest Hills station.

2.3.4. Quality of Service

The quality of existing transit service was evaluated by using criteria described in the *Transit Capacity and Quality of Service Manual*[5]. The manual lists several different measures of service quality for both route level and system level analysis. The analysis used the Level of Service (LOS) criteria to describe the Quality of Service as noted in Table 7.

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[5] *Transit Capacity and Quality of Service Manual First Edition*, Transit Cooperative Research Program, 1999

Table 7 – Transit Level of Service Criteria

LOS	Measure	Comment
	Service Frequency	
A	<10 minute headway	Passengers don't need schedules
B	10-14	Frequent Service, passengers consult schedules
C	15-20	Maximum desirable time to wait if bus/train missed
D	21-30	Service unattractive to choice riders
E	31-60	Service available during the hour
F	>60	Service is unattractive to all riders
	Hours of Service	
A	19-24 hours per day	Night or owl service is provided
B	17-18	Late evening service is provided
C	14-16	Early evening service is provided
D	12-13	Daytime service is provided
E	4-11	Peak hour service/limited midday service
F	0-3	Very limited or no service

Source: *Transit Capacity and Quality of Service Manual First Edition,* Transit Cooperative Research Program, 1999

Note: 1. Choice Riders are riders who have a choice of transit or auto. Does not include transit dependent population that does not own an automobile.

Transit service on Route 39 is frequent and operates for almost 20 hours of the day. Based on the above criteria, the Route 39 Quality of Service measures up extremely well: an LOS of A for service frequency and an LOS A for hours of service. This service requires a transfer to enter the central subway system. Weekday service on the other routes, not including the Route 37, would have an LOS of C/D for service frequency. The LOS for hours of service would range from LOS B for Route 38 to LOC C for the Route 42 to LOS E for the Route 48, which is a midday-oriented service.

3. TRANSIT TRENDS AND EXPERIENCE

A review of industry standards was conducted of historical and current transit trends regarding the design, construction and operation of transit systems in exclusive, semi-exclusive and non-exclusive rights-of-way to highlight the evolution of transit agency practices. Contacts were made with the Federal Transit Administration, designers of recent transit projects and by performing a literature review. In conjunction with this effort, a series of interviews with transit agencies in San Francisco CA, New Orleans LA, and Portland OR were conducted to obtain similar information for projects currently under design or construction. Major findings include:

- During the past century, transit agencies have migrated their systems towards exclusive and semi-exclusive rights-of-way and away from non-exclusive right-of-way (street running) [6].
- Street running systems introduce another dissimilar element into an already complex traffic stream, presenting potential problems in terms of safety, schedule reliability, lower operating speeds and reduced capacities, principally in developed urban areas.[6]
- Street running system such as streetcars and trolleys which share the same street space as motor vehicles, typically do not have the level of schedule adherence and operating speed that exclusive and semi-exclusive systems offer. Street running systems are influenced to a far greater degree by motor vehicle and pedestrian traffic, which can impede transit operations.[6]
- For the few transit operators that have designed or constructed new street running transit lines, the majority of the streets so utilized feature wide cross sections that have adequate width and capacity to accommodate the combined transit and motor vehicle demand.[6]

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[6] Herbert S. Levinson, *Street Running Rail Transit: A Historical Perspective.* Transportation Research Record No. 1503, 1995.

- Our investigation indicates that street running transit systems constructed in narrow urban streets are typically part of a historical trolley or tourist oriented streetcar system, or local circulator that have lower levels of on-time performance and operating speed as compared to systems with exclusive and semi-exclusive rights-of-way. They are usually designed as small separate self-contained systems that operate in coordination with, but independent of the larger regional transit system which require a high degree of reliability. [6]

3.1. Historical Trends

The overall trend toward the reduction of street running is evident in Boston with the western extension of the subway system to Kenmore Square in 1925 and beyond in 1932. The opening of the Huntington Avenue subway in 1941 coincided with the elimination of street running in the center of Boston when the Boylston Street trolley incline was discontinued. This practice was continued when the LRT extension to Riverside was constructed on the old Highland Branch railroad ROW. Similar transit migrations have also occurred to systems in Newark NJ, Pittsburgh PA, and in San Francisco CA where part of the Market street line was relocated underground.

3.2. San Francisco CA

San Francisco Municipal Railway (Muni) is the seventh-largest public transit system in the United States, as measured by ridership. Muni has approximately 700,000 boardings on an average weekday. Its fleet of about 1,000 vehicles, over half of which are electric, consists of subway-surface light-rail vehicles (Metro streetcars), electric trolley buses, diesel buses, the world-famous cable cars (the only ones in the world still operating) and a unique collection of historic streetcars (restored PCC's). This study examined the current operation of LRV's (Metro Streetcar) in mixed traffic on the J Line (Church Street) and the proposed operation of the 3rd Street Line, which is under design and scheduled to open (in phases) in 2004.

No new street level systems are planned for mixed traffic lanes where roadway curb to curb width is less than approximately 60 - 70 feet because of the need to accommodate multiple competing demands on the existing street cross-section including: ADA compliant stations, passengers, pedestrians, vehicular traffic and parking.

The Metro Streetcars operate on the five major lines (J, K, L, M, N) which consists of subway and surface operations (street running in mixed traffic; street running in a center reservation; semi-exclusive and exclusive ROW). The system is undergoing a renovation program to make selected "Key" Metro Streetcar Stations ADA accessible since the existing system predominately features high level station platforms.

Overall, operating the Metro Streetcars in mixed traffic necessitates achieving a balance between competing demands for limited street space. A substantial section of the existing J Line operates at street level in a center alignment in mixed traffic (approximately 58 feet wide curb to curb). One short segment of the existing M Line operates in a center alignment in mixed traffic where the curb to curb width is approximately 40 feet. No curbside parking is permitted along this segment.

J Line (Church Street)

The existing J Line (Church Street) has a significant section that operates in mixed traffic. The surface section (south of Market Street) operates at street level in a center alignment in mixed traffic, loading and unloading passengers into the street. Church Street features 2-way traffic and is approximately 58 feet wide curb to curb. A typical cross section is as follows in Table 8 below:

Table 8 – Typical Cross Section – J Line

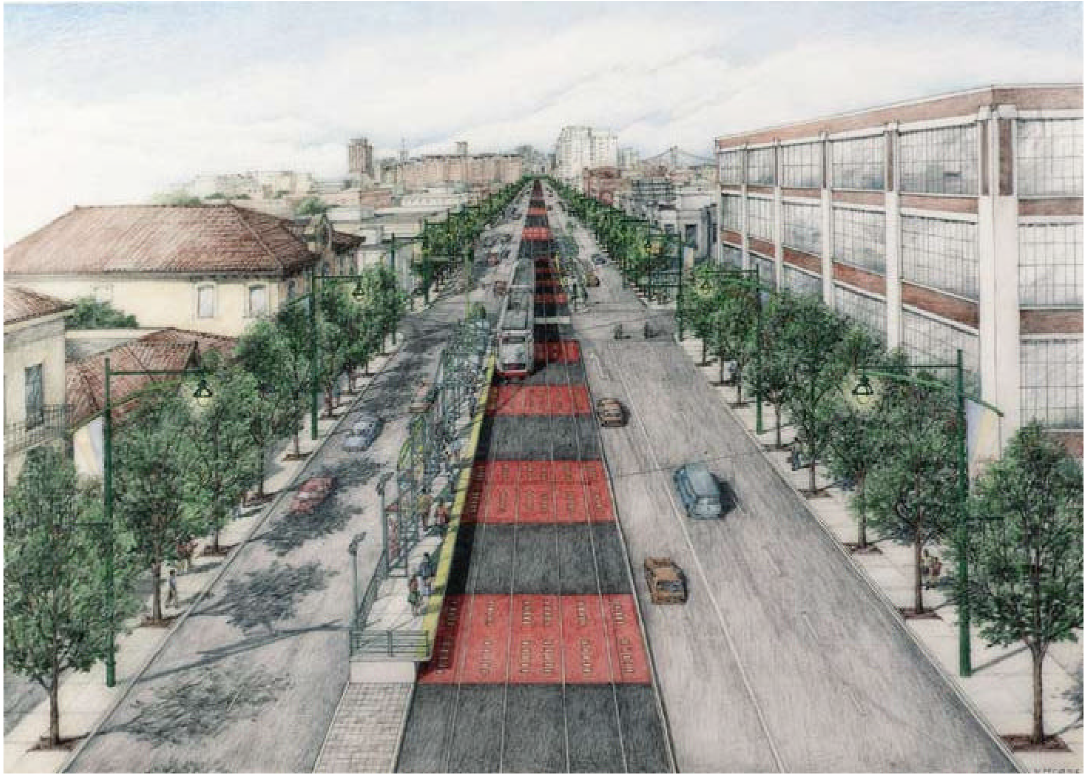
Typical Cross Section - J Line Church Street in mixed traffic (58 ft curb to curb)						
Lane Type	Parking	Traffic	LRV/Traffic (mixed traffic)	LRV/Traffic (mixed traffic)	Traffic	Parking
Width (ft)	8	10	11	11	10	8

Several short street level segments of the J Line in mixed traffic are narrower, however this typically occurs at corners where there are sidewalk bulbouts or the track turns around a corner. Delineation of roadway areas restricted only to the Metro Streetcars is primarily accomplished through roadway striping as visibility concerns due to snow or ice is not a problem.

Third Street Light Rail Project

This project, currently under design, predominately features a street level center alignment with island stations. Segments of the project are designed to operate in a semi-exclusive center reservation (as shown below) while other segments are designed for street running operation in mixed traffic. Phase 1 is scheduled to open for service in 2004.

Phase 1 will extend Muni Metro light rail service south from its current terminal at Fourth and King Streets. The line will cross the Fourth Street Bridge and run along Third Street (a major arterial) and Bayshore Boulevard, ending at the Bayshore CalTrain Station in Visitacion Valley. Tracks will be constructed primarily in the center of the street to improve safety and reliability and 19 stops (staggered stations located at the far side at intersections) will be provided. This phase of the light rail project is expected to open for service in 2004. 71,000 riders per day are projected for 2015 and the entire project is 5.4 miles long.



Aerial perspective of Third Street Light Rail project (courtesy of Muni)

Along Third Street in the Bayview Commercial Center, the light rail project will provide special "Main Street" pedestrian-oriented improvements, in conjunction with the City's revitalization efforts. These will include widened sidewalks with special artist-designed paving patterns, distinct neighborhood trees, seating and pedestrian lighting as shown in the previous illustration. Dimensions for a typical cross section where the system will operate in mixed traffic are provided below in Table 9.

Table 9 – Typical Cross Section – Third Street Light Rail Project

Typical Cross Section – Third Street Light Rail Project Landscaped Median in Mixed Traffic (100 ft. property line to property line, 76 ft curb to curb)									
Use	Side Walk	Parking	Traffic	LRV/ Traffic (mixed traffic)	Median	LRV/ Traffic (mixed traffic)	Traffic	Parking	Side Walk
Width (ft)	12	8	11	13	12	13	11	8	12

Other

The N Line (along the Embarcadero) operates in the street with a center reservation. The reservation is raised 4 inches vertically above the street and features a mountable curb along its length. The reservation features a washed concrete finish (aggregate exposed) that provides a positive visual and tactile notice to motorist that it is not a regular travel lane. The curb and surface are designed for use by emergency vehicles or general traffic in an emergency or when the regular travel lanes are blocked by an accident.

3.3. New Orleans LA

The New Orleans Regional Transit Authority's Canal Streetcar Line will consist of 4.7 miles of double track operating in the "neutral ground", or median of Canal Street. The line will extend from the Mississippi River to City Park Avenue on Canal Street and along Carrolton Avenue from Canal Street to Beauregard Circle at Esplanade Avenue. Canal Street in an arterial with 170 foot ROW and the tracks will run in the "neutral ground" which is 46 feet wide in the CBD and 31 feet (proposed 35) wide in the northern section of the line.

Dimensions for a typical cross section in the Downtown area where the system will operate in the median are provided below in Table 10.

Table 10 – Typical Cross Section – Canal Streetcar Project

Typical Cross Section – Canal Streetcar Project Streetcar Operates in Semi-Exclusive Median (170 ft. property line to property line, approx. 138 ft. curb to curb)											
Use	Side Walk	Parking	Traffic	Traffic	Traffic	Median (includes double track)	Traffic	Traffic	Traffic	Parking	Side Walk
Approx. Width (ft)	16	10	12	12	12	46	12	12	12	10	16

The $136 million light rail Canal Streetcar Project will return streetcar service to Canal Street, the city's major thoroughfare and backbone of the transit network, after more than 35 years absence. The streetcars will replace the local bus service along this corridor, however express buses will continue to serve the area. The line includes 31 stops that are spaced approximately 700 feet apart and projected ridership is 29,000 to 30,000 in initial operation, growing to 31,600 in 2015.

The 24 new streetcars, operating as single car consist (72 person capacity), will closely resemble the historic Perley Thomas 900 Series cars that currently operate on the St. Charles Streetcar Line, and which ran on Canal Street until that line was discontinued in 1964 (segments of the St. Charles Streetcar Line also operate in the "neutral ground" on St. Charles Street and individual streetcars are available for charter). Traditional in appearance, they will meet all requirements of the Americans with Disabilities Act for mobility impaired passengers. The cars will feature modern parts and will be air conditioned for rider comfort.

Construction of tracks on Canal Street, from Baronne Street to North Salcedo Street, will begin in the spring of 2001. By late 2001, construction will begin on a new Service, Inspection and Storage (SIS) facility at the existing A. Philip Randolph site on Canal Street. Full passenger operations on the Canal Street portion, as well as the Carrollton Spur, are scheduled for early 2004.

3.4. Portland OR

In Portland Oregon, several rail transit projects are currently under design and construction. One project, by the Tri-County Metropolitan Transportation District of Oregon (Tri-Met), is a modern LRT system in a semi-exclusive ROW within a street with a curb to curb width of approximately 80 feet and a center reservation of 28 feet. This system was designed to maximize schedule reliability and operating speed and is an integral part of the 33 mile MAX Light Rail system which extends across the city, connecting the western and eastern suburbs with downtown Portland.

The second transit project, Portland Streetcar, will operate in one region of downtown Portland and serve as a "neighborhood circulator", a fundamentally different function than the existing MAX Light Rail system and costing considerably less per mile than light rail. Scheduled to open in the summer of 2001, this system was designed to be compatible with the architectural and historic character of the established residential neighborhoods, commercial and educational districts and fit in with the size and scale of narrow streets. It was developed as a separate subsystem within the city's transit system, recognizing the potential for significant schedule variability and slower operating speeds. Portland Streetcar will operate in mixed traffic on two-way (typical curb to curb width of approximately 40 feet) and one-way streets (curb to curb width of approximately 45 feet).

The following are several Portland Streetcar operating characteristics:

- Vehicle - Streetcar vehicles can carry a load of up to 100 passengers, are 66 ft. long (1/3 the length of a MAX double car train), air conditioned and have a low-floor center section with full handicapped accessibility.
- Route - Streetcars will run on a 2.1 mile route from Good Samaritan Hospital at N.W. 23rd Avenue, on Lovejoy and Northrup, through the Pearl District and on 10th and 11th Avenues to a S.W. Mill Street Terminus at Portland State University. A 0.3 mile extension to the PSU Urban Center is planned.
- Stops - Streetcar stops will be located every two or three blocks.
- Times - Streetcars will run from 6:00 a.m. to midnight, seven days a week.
- Frequency - Streetcars will run every ten minutes during most of the day and less frequently in the evening.
- Fit the scale and traffic pattern of existing neighborhoods.

4. DESIGN GUIDELINES

The significant design guidelines that are applicable to the proposed service were investigated and are noted below. Major design parameters that are fundamental to the restoration of service include the requirements that the transit service be fully accessible to persons with disabilities, and that it provide safe, reliable and timely service to the Arborway corridor and the subway system. The balancing of system goals and design guidelines is a major task.

It is noted that the "wide variety of operating conditions and alignment types found on even a single LRT line reflects trade-offs among performance, cost and community acceptance. Specific planning and design goals are often at odds with one another and must be reconciled in system development. These goals, all of which relate closely to alignment types and decisions, include minimizing development costs, minimizing operating conflicts, maximizing operating speeds and serving the greatest number of potential riders"[7]

4.1. ADA and AAB

The restoration of LRT service in the Arborway corridor must comply with the current requirements of the Americans with Disability Act (ADA) and with the regulations of the Massachusetts Architectural Access Board (AAB). The essence of these requirements is that all elements of a public transportation system be readily accessible to and usable by individuals with disabilities. These access requirements preclude the reconstruction of the track and non-ADA compliant platform facilities as they existed prior to the suspension of service. A letter from the AAB is included in the Appendix A. The restoration of service to the Arborway corridor will require the design and construction of ADA compliant service, including stations and platforms.

4.2. MBTA

In addition to the ADA and AAB requirements, the restoration of LRT service must comply with the guidelines, standards and codes of: *MBTA Guide to Access; MBTA Manual of Guidelines and Standards; MBTA Standard Specifications* and all applicable Federal, State and Local regulations and statues.

As part of the *Light Rail Accessibility Program for the Green Line*, the MBTA is currently bringing existing stations on the "B", "C", "D" and "E" Branches of the Green Line into compliance with the program. Restored LRT service for the Arborway corridor will also have to comply with this program.

4.3. Light Rail Transit Planning

Typical track alignments include exclusive, semi-exclusive and non-exclusive options. An exclusive alignment would maximize safety, reliability and operating speed by providing for full grade separation of all vehicular and pedestrian crossings. A semi-exclusive alignment would offer moderate safety, reliability and operating speed by providing for a separate or protected LRT ROW, limited grade crossings and limited operating conflicts. The non-exclusive (street running) option would operate in mixed traffic within the existing street ROW but would have numerous grade crossings and operating conflicts with motor vehicles and pedestrians.

From a safety perspective, the use of *exclusive* or *semi-exclusive* ROW on a separate alignment is preferred. This approach maximizes speed, capacity and service reliability while minimizing interferences and conflicts with motor vehicles and pedestrians. Where physical or cost considerations require operation in shared rights-of-way, the amount of physical separation from motor vehicles and pedestrians should be maximized[8].

Within a *non-exclusive* ROW, the alignment can be located in the center of roadway (median) or curb line (side-running). There are significant safety, reliability and operational issues to be evaluated as part of the location decision. Median alignments are preferable to curb line alignments since with median alignments the tracks are located where most road users expect them, it minimizes the impact on driveways and curb access, and provides a recovery area for errant pedestrians who step off the curb[9].

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[7] Integration of Light Rail Transit into City Streets, TCRP Report 17, Transportation Research Board, 1996.

[8] Ibid.

4.4. Bicyclists

The Massachusetts Highway Department and the American Association of State Highway and Transportation Officials guidelines note that "For all roadways where bicycle travel is permitted, planning and design should consider provisions for bicycling." Bicycle lanes (5 feet wide), if provided, must be placed between the parking area and the travel lane, and provided on both sides of two-way streets. Design features that can make roadways more compatible to bicycle travel include: bicycle-safe drainage grates and bridge expansion joints, improved railroad crossings, smooth pavements, adequate site distances, and signal timing and detector systems that respond to bicycles.

5. PROPOSED CONCEPTUAL DESIGN

As previously outlined in Section 4, Design Guidelines, a number of issues were considered as part of the potential design concepts including: vehicle characteristics; basic station dimensions; track alignment (exclusive, semi-exclusive or non-exclusive); track location (center or curb line), and station location (island station or side station).

5.1. Vehicle

The proposed concept for the restored LRT service was configured to meet the previously noted design requirements using the new low floor Type 8 LRV. The Type 8 vehicles are 74 feet long and feature three doors on each side with the front door servicing the high floor area and the two central doors accessing the low floor area of the vehicle. The central doors, equipped with a deployable bridge plate, will be accessible to people with disabilities. A significant feature of the Type 8 vehicle is a bridge plate that can be deployed 18 inches from the edge of the vehicle and descend 6 inches below from the floor to the top of the station platform. The bridge plate can only be deployed by the train operator and provides ADA compliant accessibility to the low floor area of the vehicle. Current fare collection policies of the MBTA require payment at the right front door of the vehicle unless the fare was previously collected.

5.2. Basic Station Dimensions

Green Line design standards call for stations to accommodate three-car train sets in the future. Stations will be upgraded so as to accommodate three car trains as they undergo reconstruction to meet ADA regulations. On the Arborway corridor, however, the MBTA is willing to consider two-car train sets, in order to minimize some of the impacts of restoration that are described below. This would result in either E Branch trains continuing to operate as two-car sets in the central subway system or in having one car from a three-car set uncoupled and stored (possibly at Heath Street) while the other two cars continue to Forest Hills and return. The latter alternative would have impacts on passenger convenience, including possible loss of a one-seat ride, and scheduling impacts.

At stations, two-car train sets require a 150 feet long platform to accommodate passenger loading and unloading with all doors to aligning with the platform. This length includes a 5-foot buffer on either side of the stop bar (10 feet total) to accommodate LRVs which stop just short of or just over the stop bar. The use of a shorter platform that only extends the distance between the low floor doors, or only extended the length of one car, is not acceptable since passengers departing the vehicle from the doors which do not align with the platform, would be discharged into parked vehicles or other potential obstructions. This condition compromises the light rail transit guideline that for on-street operations, passengers load or unload from or onto the sidewalk or a protected, raised median platform and not from the roadway itself.

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[9] Ibid.

For a typical new ADA compliant station, the minimum platform width is determined by the requirement to maintain a platform clear zone of 5’1” around each of the deployed ramps (bridge plate). This distance plus the ramp length, produces a minimum platform width of 6’2”. Typical minimum platform dimensions and vehicle clearances are shown in Figure 5.

The floor of the Type 8 vehicle is 14 inches above top of rail and in combination with the bridge plate, the minimum platform height is 8 inches. Limiting the platform height of 8 inches in turn minimizes the length and size of the transition ramps needed to access the platform, there by reducing the total size of the station.

The total space occupied by the station in the street is greater than the length of the station platform (150 feet) by itself. Also included in the overall length are; transition ramps; curb ramps and crosswalks, depending where the station is located on the street. The slope of transition ramps is limited to 5 percent (1:20) and the slope of curb ramps is limited to 8 percent (1:12). Incorporating the above, island stations have a minimum length of 185 feet and side stations have a minimum length of 200 feet.

5.3. Track Alignment

The corridor features a built-up urban environment and relatively narrow streets that are used by cars, trucks, buses, pedestrians, bicyclists, residents, businesses and visitors.

An exclusive alignment would essentially sever the community in half along the Arborway corridor by requiring all pedestrian or vehicular crossing traffic to either cross under or over the alignment. Due to the relatively narrow curb to curb width of Centre and South Streets, a semi-exclusive alignment could require a choice between vehicular traffic or parking on those two streets. The non-exclusive (street running) alignment option would operate in mixed traffic within the existing street ROW but would have numerous grade crossings and operating conflicts with motor vehicles and pedestrians, thereby resulting in lower safety, reliability and operating speeds.

Recognizing the established physical features of the corridor, there is insufficient public rights-of-way for the construction of an exclusive or semi-exclusive LRT alignment, therefore the proposed LRT system features a non-exclusive (street running) alignment, operating in mixed traffic and sharing the travel lane with other vehicles.

5.4. Track Location

Track location alternatives were considered including: tracks in the center of roadway; tracks along the curb line; and tracks in the center of the roadway with side stations. These concepts were discussed extensively at the first public meeting held for this study.

5.4.1. Tracks in Center of Roadway

The placement of tracks in the center of the street allows curbside parking to remain, and where a wide roadway cross sections exist, vehicles can pass the LRV, such as on South Huntington Avenue. In narrower roadway cross sections of Centre and South Streets, the LRV and motor vehicles share the same travel lane. The location of tracks in the center require the placement of island stations (ADA compliant) to provide a protected area for patrons to wait or load and unload from the LRV and a minimum width of 32 feet to contain the station and LRV. Only on South Huntington Avenue and Center street would vehicular traffic be able to pass the LRV on the right, but on-street parking would have to be eliminated.

Restoration of Light Rail to the Arborway

Low Floor Vehicle/Platform Clearances

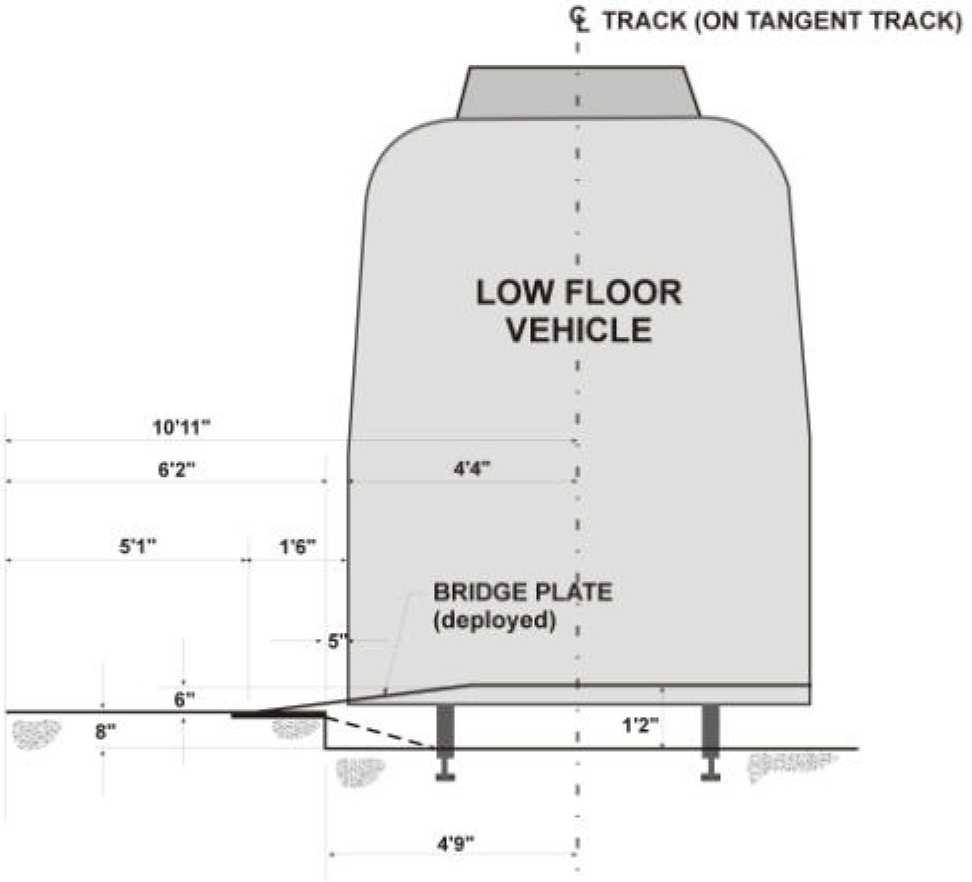

Figure 5

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

5.4.2. Tracks along Curb Line

The placement of track along the curb line facilitates traffic flow by allowing vehicles to pass the LRV but would eliminate all curbside parking, loading/unloading, and deliveries along the entire Arborway corridor. Any obstruction, such as a vehicle temporarily parked along the curb, would serve to effectively block the path of and delay the LRV. As previously noted in Section 4, Design Guidelines, median alignment of the tracks is preferable to a curb line alignment. At the request of businesses and residents along the corridor at the first public meeting, this alternative was not pursued further.

5.4.3. Tracks in Center of Roadway with Side Stations.

The last alternative examined the placement of tracks in the center of the street with side stations located at the curb. This alternative allows curbside parking to remain, except at stations, and enables vehicles to pass the LRV at locations where a sufficient roadway cross section exists such as on South Huntington Avenue.

The proposed stations, shown in Figure 6, are situated in comparable locations to those previously noted in the 1988 BTD report[10]. The 1988 report describes the potential location of the LRT stops and developed the "Trolley Plaza" concept that has been incorporated into the current proposed station design to meet ADA requirements. Each proposed station has two stops, one southbound and one northbound for a combined total of 21 LRT stops (10 stations in each direction plus the terminus Forest Hills station).[11] Final location of the proposed stations is subject to further refinement.

5.5. South Huntington Avenue

South Huntington Avenue features a 54-foot curb to curb roadway width and as such, two station location alternatives were considered: island stations and side stations, shown in Figures 7 and 8 respectively.

An island station located in the center of the street would extend down the street for 185 feet, including platform, transition ramp and crosswalks. At the station, an 11-foot travel lane is located to the outside of the LRV. It should be noted that the current configuration of fare collection equipment for the Type 8 vehicle is oriented for passenger boarding from the front right door. Boarding passengers from the left side of the vehicle would require reconfiguration of the fare collection equipment, or some other form of fare collection.

The side station alternative for South Huntington Avenue is shown in Figure 8, with each station placed on the far side of the intersection to minimize the blocking of the intersection approach while loading and unloading passengers. Each station platform extends out 8 feet from the curb, the width of a normal parking stall and the total length of the station is 200 feet, including platform, transition ramp, curb transition and crosswalks. A cross sectional comparison of both the island station and side station concept is provided in Figure 9.

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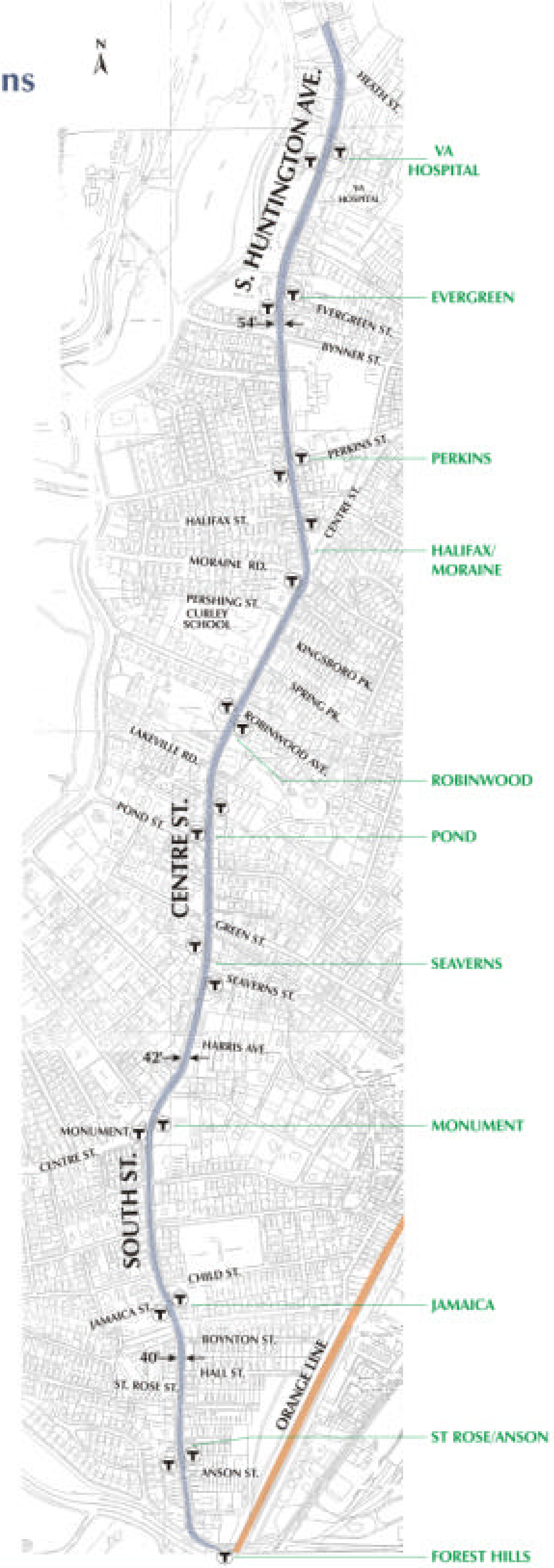
[10] Boston Transportation Department, *Arborway Corridor Study*, Bruce Campbell & Associates, Inc. 1988.

[11] LRT stops are typically spaced further apart than bus stops, hence fewer LRT stops are required to serve the corridor than bus stops.

Restoration of Light Rail to the Arborway

Location Map with Proposed Stations



KEY:

Proposed Station

Street Width

Figure 6

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Restoration of Light Rail to the Arborway

South Huntington Avenue - Island Station

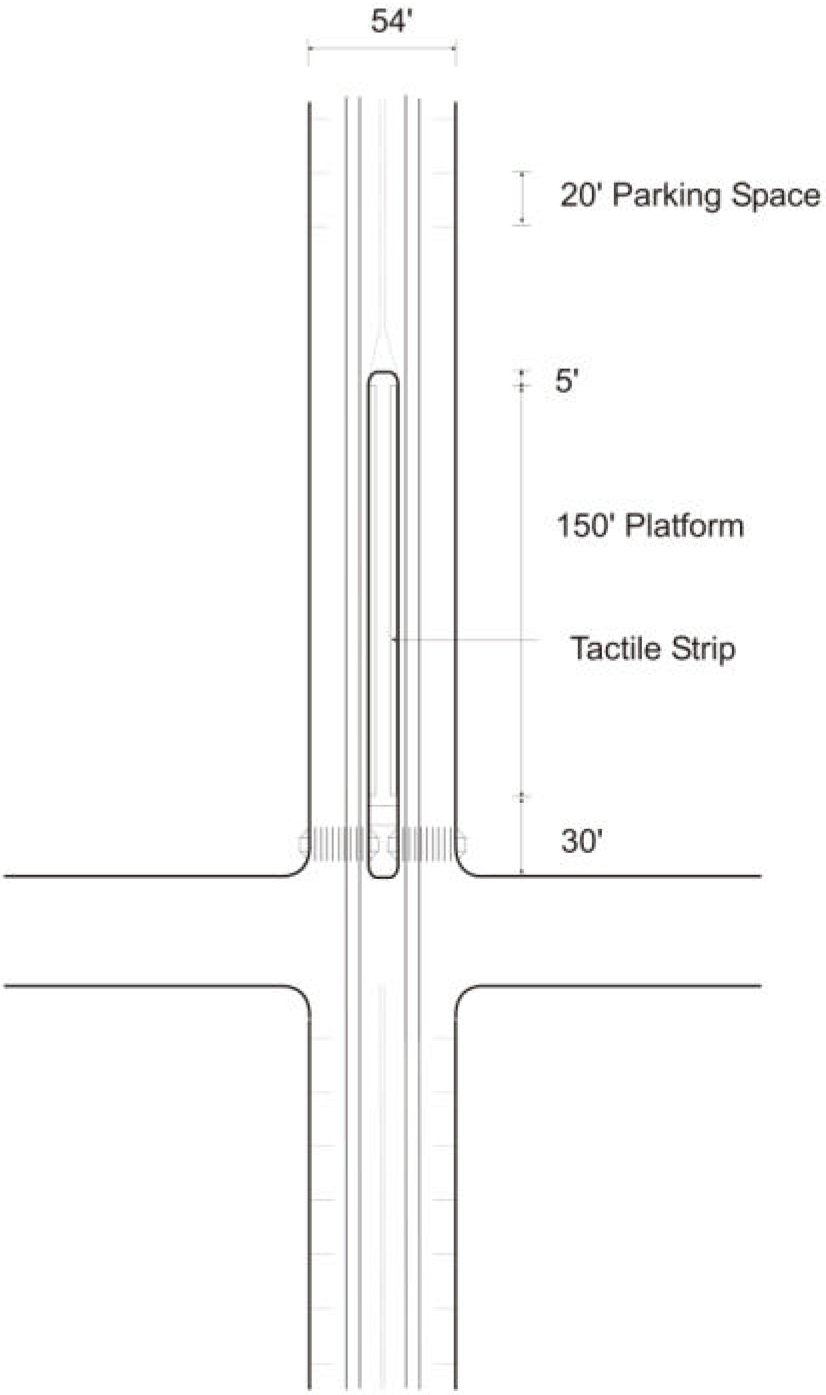


Figure 7

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Restoration of Light Rail to the Arborway

South Huntington Avenue - Side Station

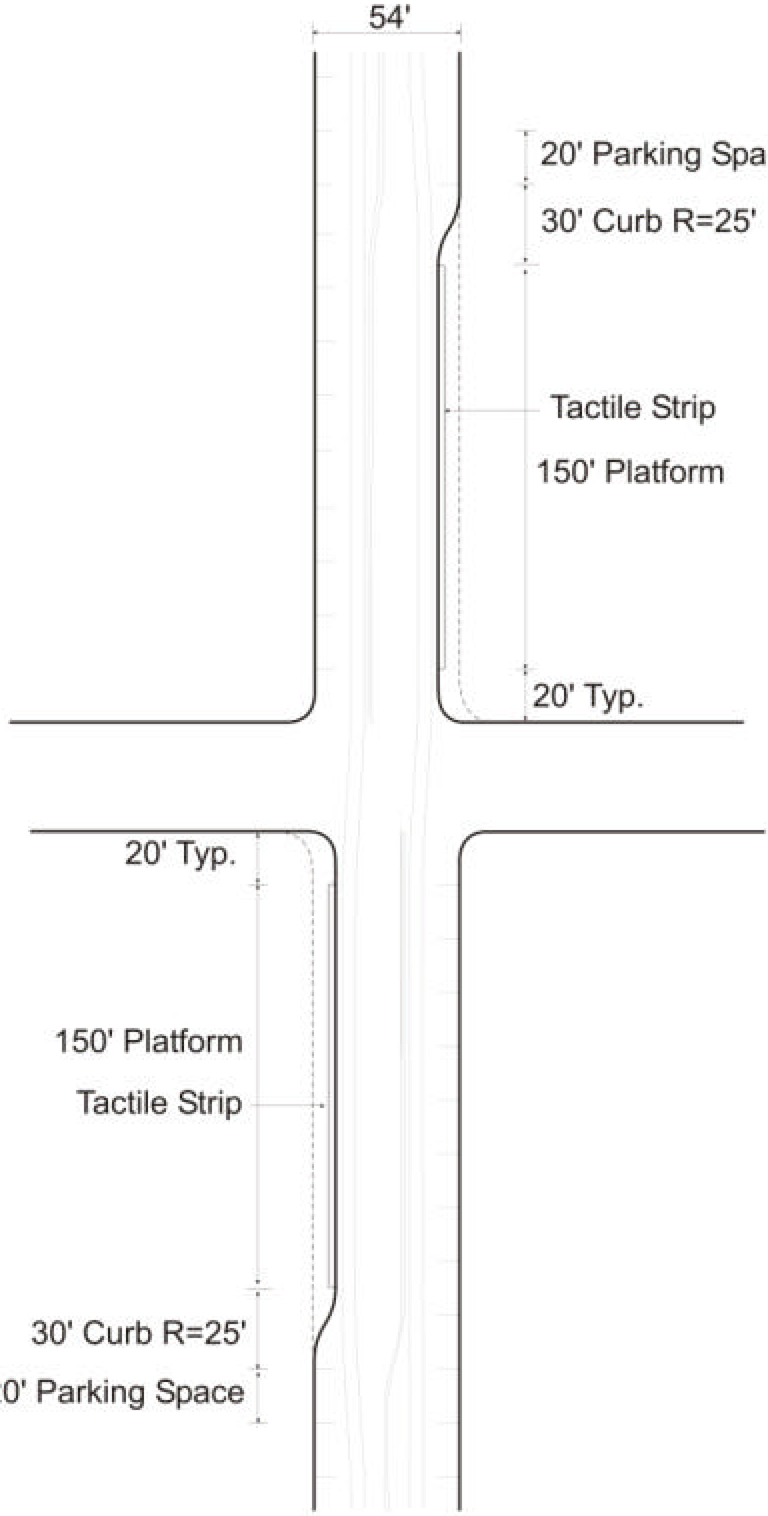
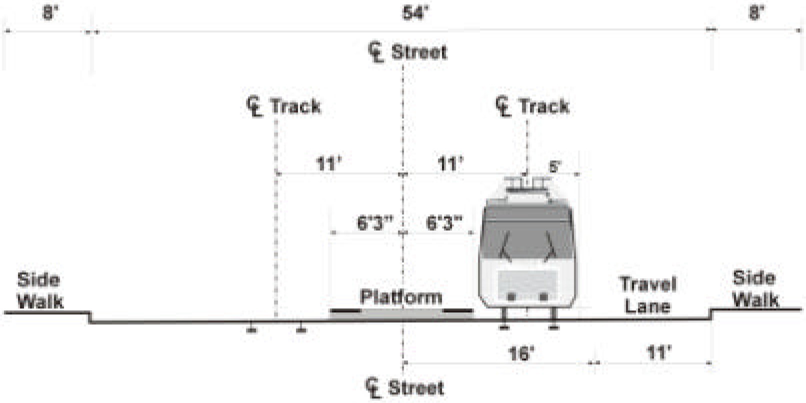


Figure 8

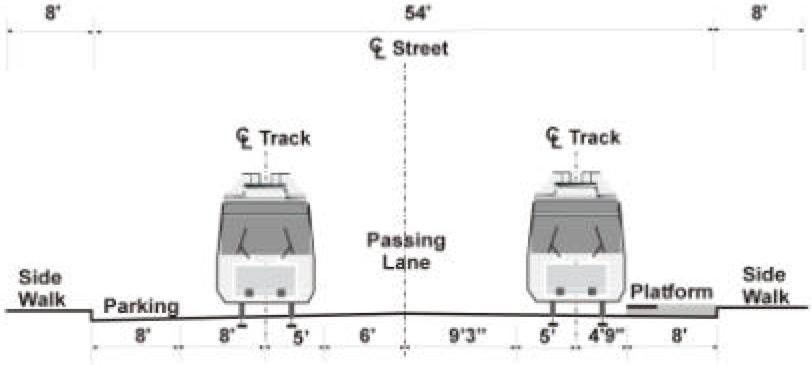
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Restoration of Light Rail to the Arborway

South Huntington Avenue



Island Station Section



Side Station Section

Figure 9

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

5.6. Centre and South Streets

Centre and South streets feature 42 and 40 foot wide roadway cross sections (curb to curb), substantially narrower than South Huntington Avenue (54 feet). As such, only the center tracks with side station layout was considered and is shown in Figure 10.

As with the same station concept for South Huntington Avenue, each station is placed on the far side of the intersection to minimize the blocking of the intersection approach while loading and unloading passengers. Each station platform extends out 8 feet from the curb, the width of a normal parking stall and the total length of the station is 200 feet, including platform, transition ramp, curb transition and crosswalks. Due to the narrow width of the street, vehicles behind the LRV will not be able to pass it without crossing the centerline of the roadway. A typical cross sectional comparison of the side station concept for both streets is provided in Figure 11.

6. INFRASTRUCTURE COST

Restoration of Arborway corridor service would require a substantial capital investment in track and roadway, power system, platforms, additional rolling stock and space for maintenance operations. The rail bed has not been maintained for over 15 years and would require a complete reconstruction along with the roadway surface. The existing catenary structure was designed for trolley pole operation and is not adequate for modern pantographs used by the Type 8 vehicle. Upgrading the power system will require replacement of the overhead wire, substations, power distribution systems and duct banks. Construction of the station platforms will require a capital investment in order to extend the sidewalk into the street and to provide passenger amenities. Each of these capital improvements will require the relocation of existing utilities.

Table 10 presents the order of magnitude costs (2001 dollars) that were estimated in the SYSTRA Consulting study. The costs are order of magnitude costs and should be subjected to further refinement if a more detailed design phase is undertaken. Other significant potential costs not included in this estimate are: roadway improvements and reconstruction, construction mitigation/management, utility relocation, and rights-of-way acquisition. Based on a study by SYSTRA Consulting[12], the restored service will require the purchase of 19 new vehicles and space for a maintenance facility.

Table 11 – Order of Magnitude Cost Estimates

Item	**Cost (2001 Dollars)**
Additional Vehicles	$45.9
Track removal and replacement	$13.3
Traction Power	$8.5
Stations	$1.6
Utility Relocation	$2.2
Maintenance Facility	$5.2
Total	**$76.7**

Source: Massachusetts Bay Transportation Authority, *Arborway Alternatives Analysis* (draft), SYSTRA Consulting, Inc., May 2001.

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[12] Massachusetts Bay Transportation Authority, *Arborway Alternatives Analysis*, SYSTRA Consulting, Inc., May 2001.

Restoration of Light Rail to the Arborway

Centre & South Streets - Side Station

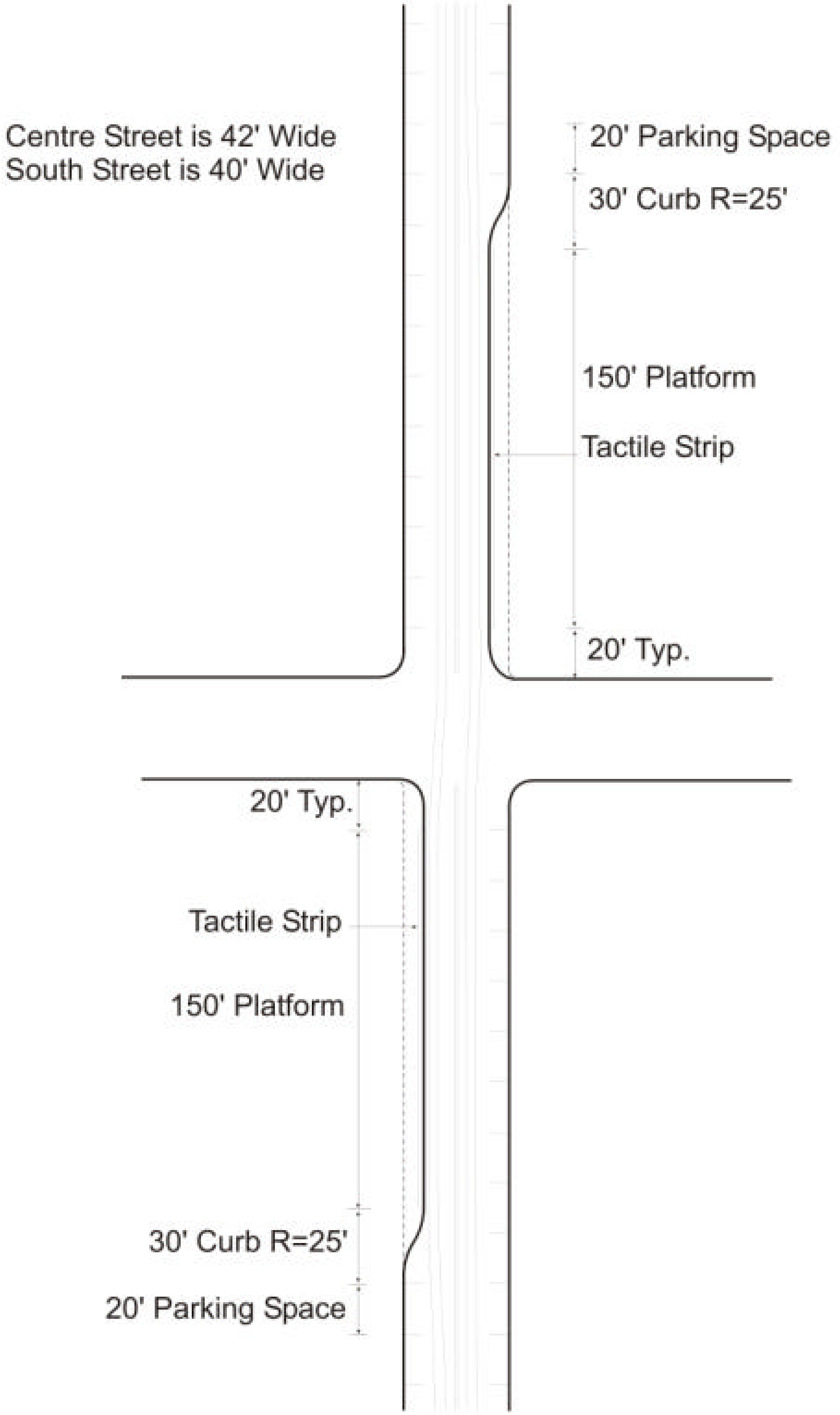
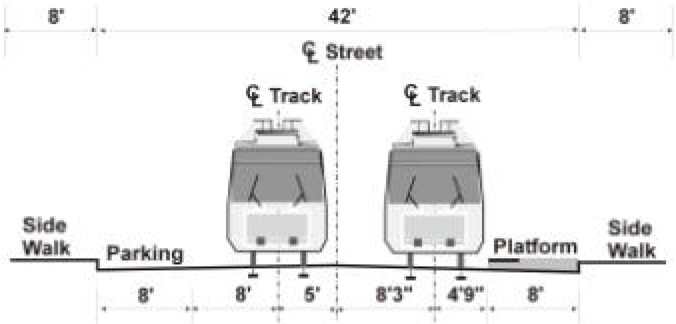


Figure 10

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

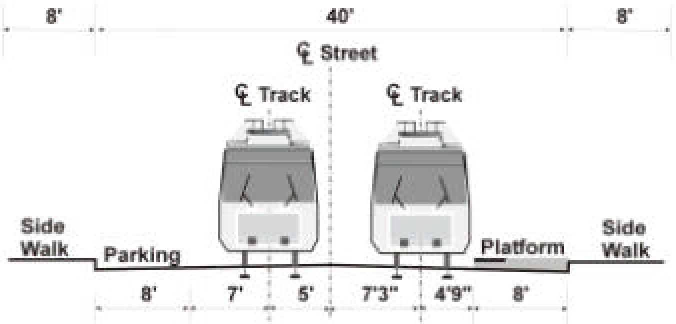
Restoration of Light Rail to the Arborway

Centre Street Section



Side Station Section

South Street Section



Side Station Section

Figure 11

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

7. ISSUES RAISED BY RESTORATION OF LIGHT RAIL SERVICE

The following issues were noted concerning the conceptual design prepared for restoring light rail to the Arborway corridor.

7.1. Potential Compromise of Design Parameters

Major design parameters that are fundamental to the restoration of service include the requirements that the transit service be fully accessible to persons with disabilities, and that it provide safe, reliable and timely service to the Arborway corridor and the subway system. Retrofitting a new LRT service (to current design standards and guidelines) in narrow urban streets (Centre Street and South Street), is to some degree in conflict with the central purpose of LRT service: "moving people efficiently and safely with an appropriate degree of comfort"[13]. Due to the relative narrowness and established environment of the Arborway corridor, the conflicts between competing interests of various users (transit vehicles, cars, trucks, buses, pedestrians, bicyclists, residents, businesses and visitors) are magnified and the potential exists to significantly compromise the central purpose for the service in the first place.

Numerous studies have documented the principle that "good alignment choices and design geometry are essential for safe transit operations. The alignment must be chosen carefully with full consideration given to motor vehicle and pedestrian travel patterns and roadway operating conditions. Where geometry is poor, traffic control devices may provide relatively little safety benefit" [14].

Recognizing this, a majority of transit systems during the past century have migrated towards exclusive and semi-exclusive transit rights-of-way as a means of enhancing safety, reliability and operating speed. For the few transit operators that have designed or constructed new street running transit lines (on non-exclusive rights-of-way), the majority of the streets so utilized feature wide cross sections that have capacity to handle the combined transit and vehicular demand. The primary reason for the reduction of light rail transit street running in mixed traffic is that the service introduces another dissimilar element into an already complex traffic stream, presenting potential problems in terms of safety, reliability, lower operating speeds and reduced capacities, principally in developed urban areas[15].

7.2. Vehicles, Tracks and Stations

Because the Arborway corridor is fully developed, every modification to the physical environment will involve competing interests, with significant trade-offs involved. Major issues are as follows:

- Given narrow width of Centre Street (42 feet) and South Street (40 feet) and the need to maintain one travel lane per direction and on street parking, an exclusive ROW is not possible. LRVs will operate in mixed flow traffic, competing with other uses of the street including cars, trucks, delivery vehicles, pedestrians and bicyclists for street space
- Due to the narrower roadway widths on Center and South streets, vehicles maneuvering into a parking space from the mixed flow lane will impede LRV operations when the transit vehicle is present. In contrast, the "E" Branch Green Line on Huntington Avenue east of South Huntington Avenue features a 60-foot curb to curb roadway where there is sufficient width for: tracks in the center of the roadway, one travel lane per direction and parking on both sides of the street. Because of the wider roadway cross section, vehicles maneuvering into a parking space from the travel lane typically do not impede LRV operations.

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[13] Manual for Railway Engineering, Volume 3, AREMA, 1999.

[14] Integration of Light Rail Transit into City Streets, TCRP Report 17, Transportation Research Board, 1996.

[15] Herbert S. Levinson, *Street Running Rail Transit: A Historical Perspective.* Transportation Research Record No. 1503, 1995.

- The restoration of service to the Arborway corridor will require the design and construction of ADA compliant service, including stations and platforms. The siting of the stations will require careful coordination in order to minimize conflicts with abutting land uses and property owners.
- At new ADA compliant stations, two-car train sets require a 150 feet long platform to accommodate passenger loading and unloading. These side stations occupy valuable street space and result in the average net loss of 6 parking spaces per station.
- At stations, bicyclists will need to maneuver between the 8-inch curb and the outside rail, a distance of approximately 2½ feet. The rail is located in the path of bicyclist and compromises the goal of providing a consistent and uniform riding surface. In order to avoid an LRV located in or approaching a station, bicyclists will need to cross the tracks to pass the transit vehicle, a potentially hazardous maneuver.
- The 8-inch curb required for the island station platforms create a potential hazard to vehicles due to its height when the island stations are located in the middle of the street.
- Snow plowing and snow removal will be required at stations.

7.3. Additional Maintenance Requirements

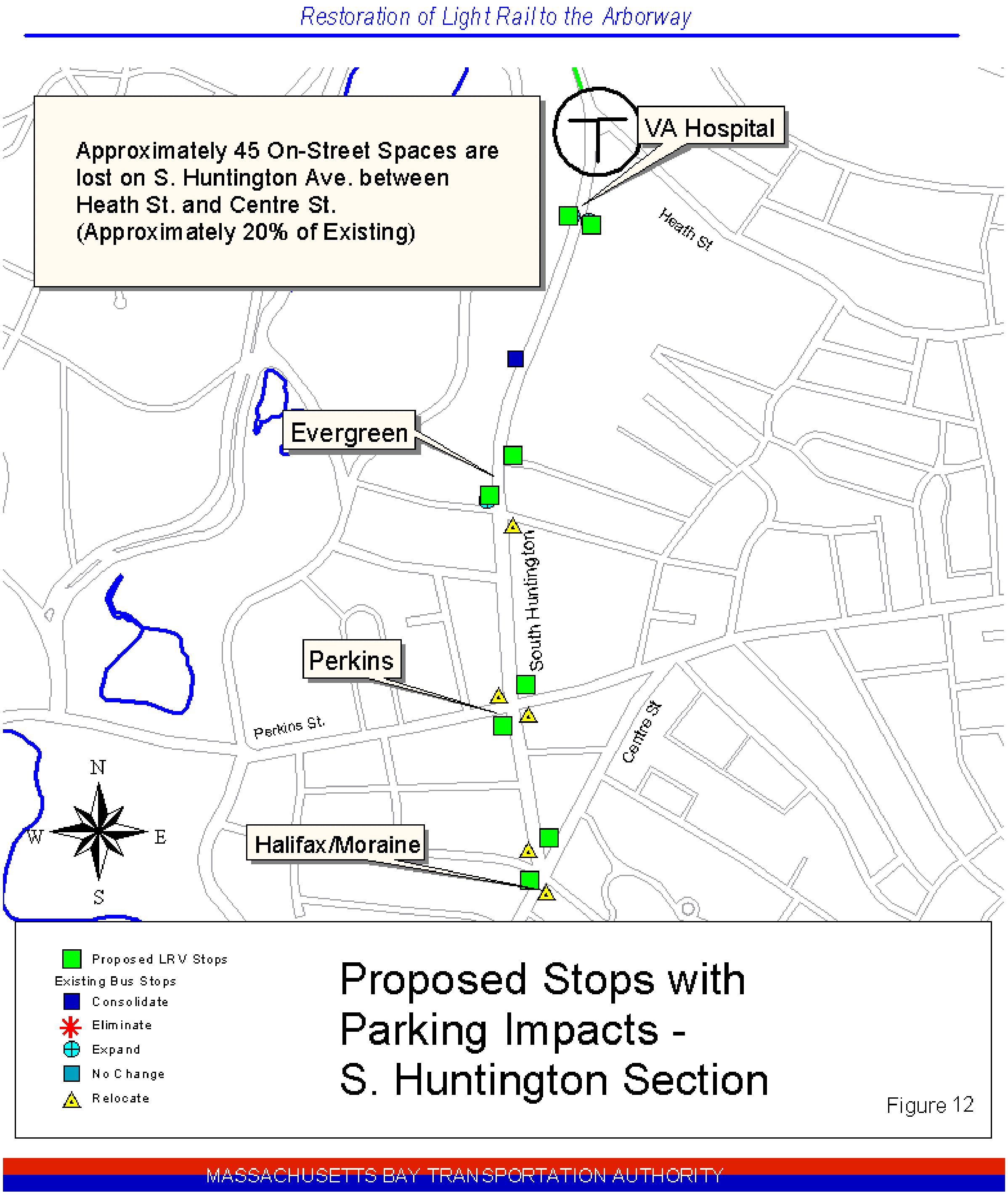
The proposed Arborway Maintenance Facility is currently in the planning stages and is proposed to be located in the vicinity of the Forest Hills station, where a portion of the facility is currently in use as an MBTA commuter parking lot. The new maintenance facility would be capable of handling CNG buses. If the LRV maintenance facility (vehicle storage, light maintenance and washing yard) is located at the Arborway yard, additional space will be required as it will have to be separate from the proposed CNG bus facility because of the combustible and “lighter than air” properties of CNG. Escaping CNG could collect at the ceiling and be ignited by the overhead electrical equipment required by LRT operation if the two vehicle types were stored in the same structure.

7.4. Parking

The impact of LRT service restoration on parking conditions in the corridor was examined. The proposed stations would consolidate 29 current Route 39 stops into 21 LRV stops (10 stations in each direction plus the terminus Forest Hills station). Each station has two stops, one southbound and one northbound. Routes 37, 38, 41 and 48 would also use the stations on Centre Street and South Street. Other existing bus stops on South Street would be retained for these routes, while the stops on Center Street would also be consolidated with the new LRT stations. The Route 39 service would be discontinued and stops on South Huntington Avenue would be eliminated.

It is estimated that there will be a net reduction of approximately 20 percent in on-street parking capacity along the corridor if the LRT service is implemented as proposed. The currently proposed station platform design will be 150 feet long. Across the corridor approximately 120 on-street parking spaces will be removed in order to accommodate the LRT stations. The 150-foot long stations are the equivalent of 8 parking spaces. However, on average, there would be a net loss of six parking spaces per platform. This net loss includes the total curb length required for the station platform minus the curb length currently zoned for "No Parking" (i.e. existing MBTA bus stops).

Each segment of the corridor will experience a reduction of approximately 20 percent in available on-street parking spaces. As shown in Figure 12, approximately 45 spaces will be lost on South Huntington Avenue, approximately 45 spaces on Centre Street and approximately 30 spaces on South Street. Table 12 compares existing on-street parking inventory to the proposed parking supply with the proposed LRT service.



Approximately 45 On-Street Spaces are lost on S. Huntington Ave. between Heath St. and Centre St. (Approximately 20% of Existing)

Proposed Stops with Parking Impacts - S. Huntington Section

Figure 12

Table 12 – Comparison of Existing On-Street Parking Inventory, Existing Versus Restored LRT Service

	Existing Conditions[1]		Restored LRT Service	
Segment	**Number of Spaces**	**Midday Occupancy Rate**	**Number of Spaces**	**Midday Occupancy Rate**
South Huntington Avenue (Heath St. to South St.)	225	68%	180	85%
Centre Street (S. Huntington St. to South St.)	215	84%	170	106%
South Street (Centre St. to Washington St.)	175	73%	145	88%
TOTAL	**615**	**69%**	**495**	**93%**

Notes: 1. Survey was conducted on December 12-13, 2000.

The impact will be most severe on Centre Street, where demand will greatly exceed supply and on South Street, where demand will just exceed the practical supply (i.e., 85 percent of practical parking capacity). South Huntington Avenue has sufficient reserve capacity to absorb the losses associated with the construction of the new stations.

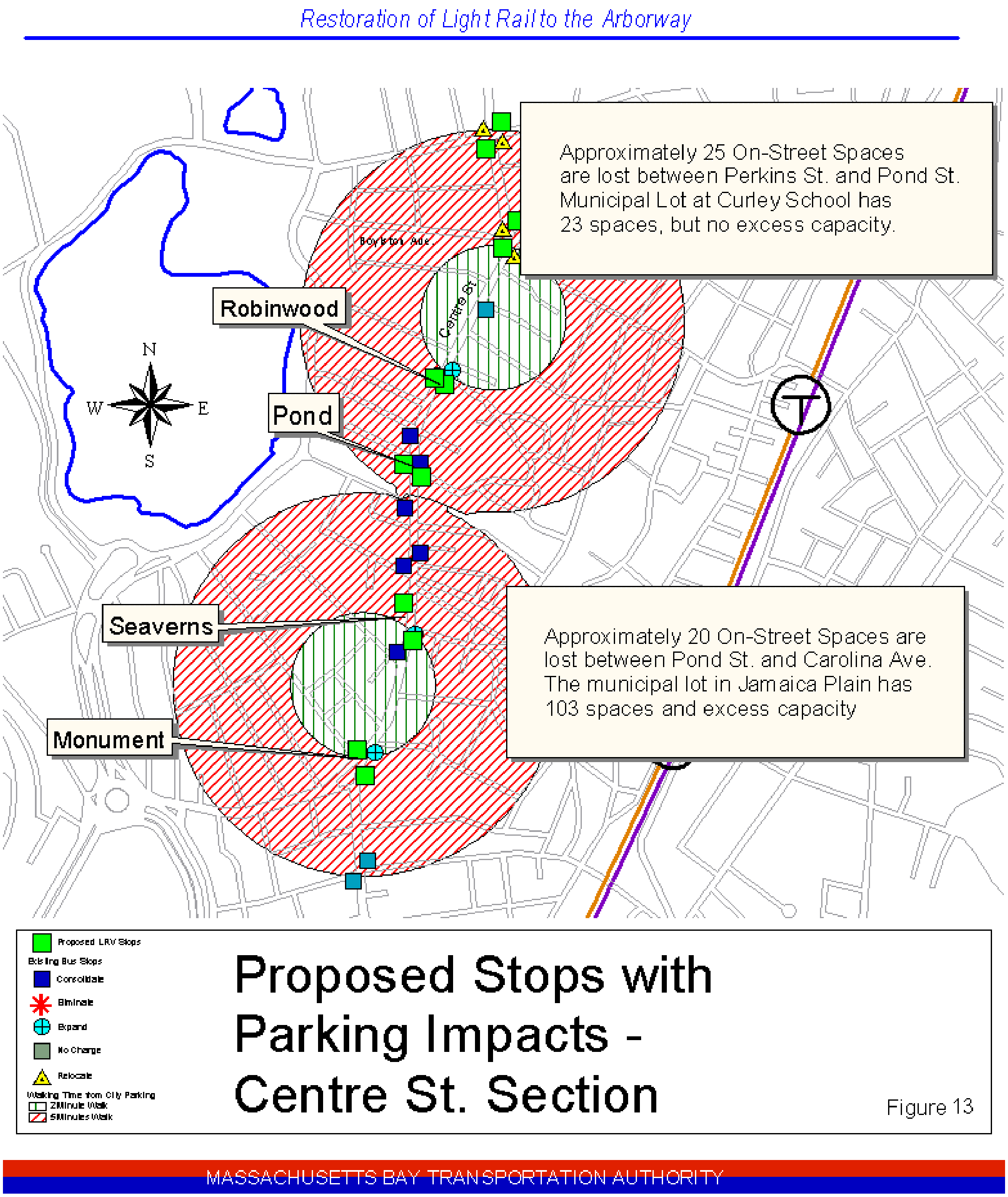
The parking loss on Centre Street will be most predominate in the vicinity of the Curley Middle School, as shown in Figure 13. Approximately 25 spaces would be lost within a five-minute walk of the municipal parking lot across the street from the Curley Middle School. As discussed earlier, this parking lot has only 23 spaces and these spaces are full for most of the day. Consolidation of the Boylston Avenue and Robinwood Avenue stations to a location near the Curley School would mitigate some of the parking impact, adding approximately fifteen spaces to the supply.

Approximately 20 on-street parking spaces would be lost within a five minute walk of the municipal parking lot that is located between Green Street and the Monument. Observations indicate that this lot should have sufficient reserve capacity to absorb this number of vehicles. However, parking in this section of the corridor will be at the practical parking capacity of 85 percent. At occupancies of 85-percent or greater, motorists may have to park further from their destination than would otherwise be desirable. This can result in motorists circling the block to look for a parking space or an increased occurrence of double parking.

As highlighted in Figure 14, parking on South Street will exceed the practical parking capacity of 85 percent. This will reduce parking availability for residents that live in this section of the corridor and increase demand on nearby side streets. The impact will be greater between Washington Street and Child Street, which is currently parked at or near 100 percent of capacity. Further consolidation of stops on South Street would reduce the impact of the lost parking. However, this would affect the convenience of the restored LRT service and the Route 37/38 service.

7.5. Delivery Requirements

There are few designated on-street loading zones along the corridor, contributing to the observed occurrence of double parking by trucks. This is a particular concern along Centre Street given the large number of businesses located along this narrower street. Double-parked trucks will delay restored LRT service and cause traffic congestion. Unlike buses, LRVs will not be able to pass double-parked trucks or trucks that infringe on the transit right-of-way. Vehicles behind a stopped LRV will not be able to pass and must wait for the truck to move from its space.

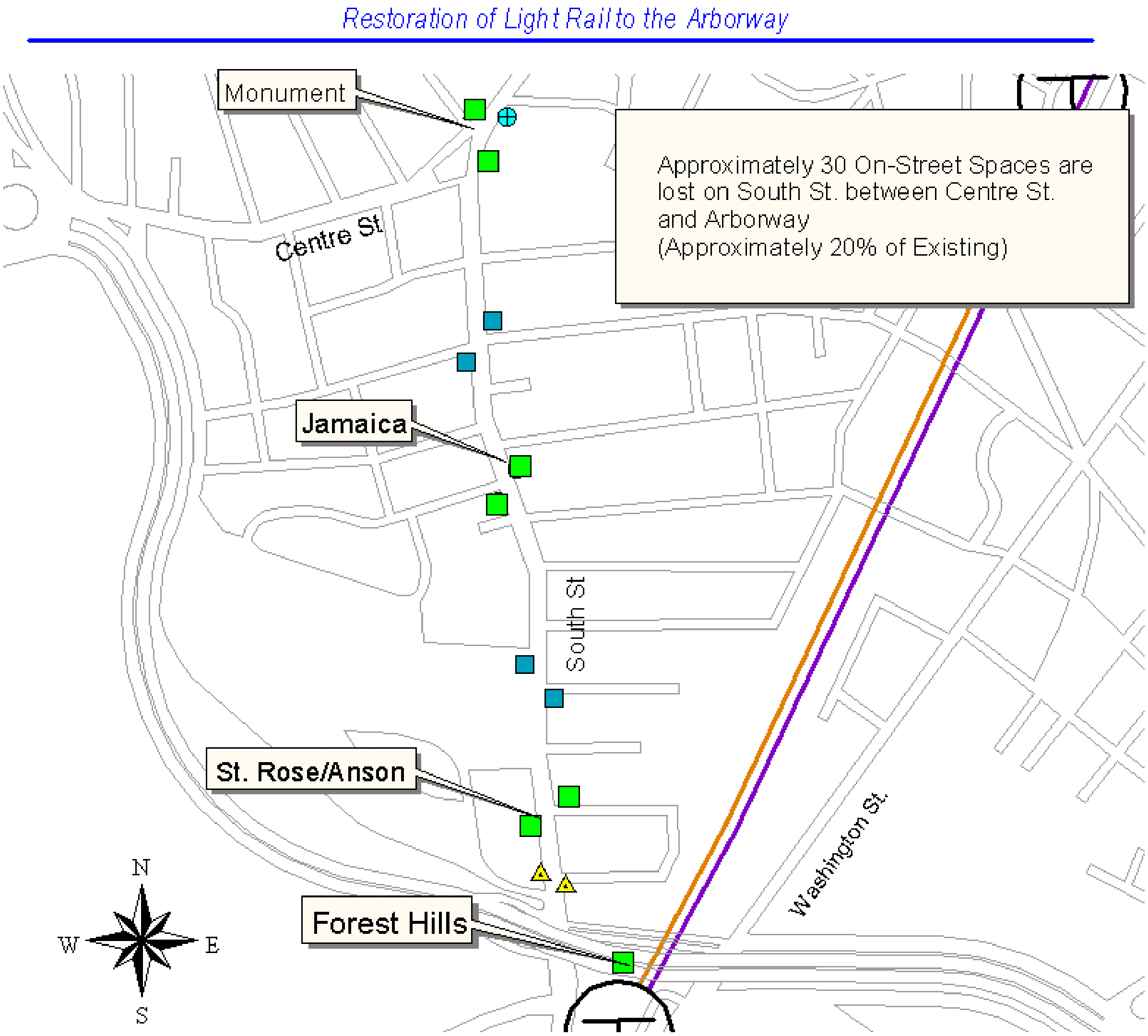


Approximately 25 On-Street Spaces are lost between Perkins St. and Pond St. Municipal Lot at Curley School has 23 spaces, but no excess capacity.

Approximately 20 On-Street Spaces are lost between Pond St. and Carolina Ave. The municipal lot in Jamaica Plain has 103 spaces and excess capacity

Proposed Stops with Parking Impacts - Centre St. Section

Figure 13



Approximately 30 On-Street Spaces are lost on South St. between Centre St. and Arborway (Approximately 20% of Existing)

🟩 Proposed LRV Stops

Existing Bus Stops

- ■ Consolidate
- ✱ Eliminate
- ⊕ Expand
- ■ No Change
- △ Relocate

Proposed Stops with Parking Impacts - South St. Section

Figure 14

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Businesses along the corridor would benefit from additional on-street loading zones to accommodate current demand. However, the additional loading zones will eliminate on-street parking and further exacerbate conditions described above. One potential approach that has been used by the BTD in other neighborhood commercial districts is the use of shared loading/parking. Loading zones could be provided during the morning and 2-hour short-term parking in the afternoon. Merchants would be encouraged to receive deliveries around the loading zone schedule. Another option is to increase the use of off-street loading through rear doors when this option is available to merchants. In any event, strict traffic enforcement will be required to prevent delays to the LRT service.

7.6. Traffic Enforcement and Snow Removal

Since the MBTA does not own the rights-of-way upon which the proposed service will operate, the City streets, the MBTA will be dependent upon the City to ensure that a high level of commitment and service is provided so that the LRT's operating goals of safety, reliability and timely service are maintained. This high level of commitment will be particularly important in the areas of traffic enforcement and snow removal, both of which have significant impact on LRT operations in the corridor.

Areas of particular concern are near the Curley Middle School, the commercial district on Centre Street, and South Street between Washington Street and Child Street. These are sections that will be at or above the practical parking capacity of 85 percent. The restoration of LRT service will reduce parking and require more effective curb management to address loading needs. Therefore, a strong commitment to an effective parking enforcement program by the City will be a necessary component of a successful parking management plan. This approach is more important for the operation of LRVs that cannot maneuver around illegally parked vehicles that encroach in the travel way than it is for buses that can maneuver around these obstructions.

Highly visible enforcement would be required during the first few months of the restored LRT service to condition the public to the new service. Regular enforcement, albeit on less intensive basis, would be needed to maintain operating conditions during normal service conditions. Support and voluntary compliance by merchants, employees, customers and delivery vehicles will also be important to ensure the success of the program.

The accumulation of snow along the curb, a result of plowing of the streets and clearance of sidewalks, reduces the width of Centre Street and South Street. The presence of snow banks can result in vehicles parking further from the curb and encroaching in the travel way that would be used by LRVs. This encroachment would delay service on the corridor and impact traffic flow. Therefore, a strong commitment to an effective snow plowing program by the City will be necessary to ensure the adequate operation of an LRT service. The narrow width of the street may require snow removal under severe storm conditions to ensure that the LRT right of way is sufficient. The need for effective snow plowing and, under some conditions, snow removal is more important for the operation of LRVs that cannot maneuver around vehicles that encroach in the travel way than it is for buses that can maneuver around these obstructions.

7.7. Travel Times and Delays

Travel time data was evaluated to determine whether the restored LRT service would impact traffic operations on the corridor. The analysis of existing conditions indicated that traffic congestion is primarily related to activities and traffic volumes on Center Street and to a lesser extent South Street including: movements into and out of parking spaces, left turns into side streets and pedestrian crossings slow traffic. The 1987 TAMS report for the MBTA reached the same conclusion.

The conditions contributing to the relatively slow traffic average speeds on Centre Street are somewhat independent of the current bus operations on the corridor. The proposed restoration of LRT service will change the operating conditions of the corridor. LRVs and buses using the new stations on Centre Street and South Street will stop in the travel lane and stop traffic behind them. Therefore the speed of traffic directly behind the LRVs or buses will be determined by operating speeds of those vehicles.

Travel time data was collected during the AM and PM peak hours for the Route 39 bus to provide a comparison with the average travel times that were calculated for the corridor. The bus data provide a reasonable approximation of likely LRT speeds since the LRT service is expected to operate at travel speeds comparable to the current bus service. Table 13 summarized the results of the travel time study for the Centre Street and South Street sections of the corridor. This section of the corridor is important, because limited roadway width requires all vehicles to stop when an LRV or bus is at a station. Proposed stations on South Huntington Avenue provide an opportunity for vehicles to pass stopped LRVs.

Table 13 – Comparison of Average Route 39 Bus and Auto Travel Times on Centre and South Streets

		North/Inbound		**South/Outbound**	
	Distance	**AM** (minutes)	**PM** (minutes)	**AM** (minutes)	**PM** (minutes)
Auto	1.3 miles	8.0	5.9	6.0	7.3
Bus	1.3 miles	6.8	7.0	5.0	8.2

LRV Travel Times

Travel times of the Route 39 or an LRT service include the time that the vehicle moves between stops in mixed traffic, the amount of time that the vehicle is stopped at a station for passengers to board or alight (i.e., the "dwell" time) and the number of stops on the route. There will be four fewer stops for the proposed LRT service. Observations indicate that the average dwell time of a Route 39 bus is approximately 15-20 seconds. The average dwell time of a two-car LRV train-set on current MBTA surface routes is approximately 30-60 seconds depending on passenger levels and whether fares are collected on board.

While headways for the proposed LRT service are under review, proposed headways of 6 to 8 minutes for the Type 8 vehicles are planned. This is comparable to headways of the Route 39 buses that currently operate along the corridor. Fare collection does not occur on the corridor in the outbound direction to Forest Hills. The LRV train-sets will have six doors available for loading and unloading passengers in the outbound direction, as compared to two doors on a Route 39 bus. Fare collection occurs in the inbound direction to downtown. The LRV train-sets will have two doors available for loading and unloading passengers in the inbound direction, as compared to one door on a Route 39 bus. This will provide comparable or greater capacity for passenger to enter or exit the LRV as compared to the Route 39 bus, allowing the LRVs to accommodate the slightly higher passenger loading that will occur because the LRVs would make fewer stops than the Route 39 buses.

Accounting for these differences between the proposed LRT service and the current Route 39 service, it is likely that the travel times for LRT service would be comparable to or faster than the bus service. This would offset a portion or possibly all of the differences between autos and buses that were observed in the PM peak hour in Table 13.

Average Delays

The delays for automobiles would occur on Centre Street and South Street where it is not possible to pass a transit vehicle at a station. As discussed above, the LRVs would take approximately 10 seconds longer than an automobile to traverse Centre Street and South Street section during the PM peak period. This estimate is based on the difference between the current automobile and bus travel times, which were adjusted to account for the reduction in stops on this section of the corridor.

Headways for the proposed LRT service are under review. Under the proposed operations, the Type 8s will operate at 6 to 8 minute headways yielding 7-10 trips per hour per direction. Existing bus routes, which will also use the stations, will account for another four transit vehicles per hour per direction during peak periods. This will result in traffic speeds being controlled by the transit vehicles at any one point along the corridor 10-14 times an hour. The delay of LRVs or buses stopped on Center Street or South Street will not be uniformly distributed over all vehicles on the corridor. Vehicles following closely behind an LRV will experience more delay than vehicles further behind the LRV. Automobiles will be able to pass stopped LRVs along South Huntington Avenue and therefore are not delayed on this section of the corridor.

The delays caused by LRVs at the stations on Centre Street or South Street were evaluated by using methodologies developed to analyze roadway delay times caused by incidents. A stopped LRV was modeled as a lane blockage since no vehicle will be able to pass the LRV. The time to return to normal flow and the average delay per vehicle in the queue behind the LRV was estimated using published delay models and observations[16,17]. This analysis indicated that there would be a total elapsed time of approximately 20 seconds between an LRV stopped at a station and a return to normal traffic flow during peak periods. This is less than half of the average travel time between stations.

Conditions on Centre Street and South Street are congested due to on-street parking activities, pedestrian crossings and the number of left-turns that occur without separate storage lanes. These conditions, which are typical of neighborhood commercial districts in Boston, will affect the reliability of Green Line transit service. The analysis of travel time data indicates that the restoration of LRT service should not have a significant impact on traffic flow on the street when the LRV travelway is not fully or partially blocked by illegally parked vehicles or other obstructions that buses would be able to maneuver around. Delays under these conditions would be experienced primarily by vehicles behind the LRV. Station locations should be reviewed further in light of this condition, since there may be potential for the traffic queues behind some stations to block side streets traffic.

Periodic Delays

Because the LRT operates on a fixed guideway (i.e., rails), the service will be more sensitive to illegally parked vehicles that block the portion of the street used by the LRV. In addition, as described below, the use of the ramp for persons with disabilities will cause delays to street operations as compared to buses that can deploy chair lifts at the curb and out of the travel lane.

Loading passengers with special needs. The Type 8 vehicle is equipped with a ramp that can be extended to allow passengers with wheel chairs to board the vehicle. The MBTA has indicated that its drivers can be expected to perform this operation in 1-3 minutes. When a passenger needing assistance is boarding, traffic along the South Street and Centre Street portions of the corridor will be disrupted

Illegally parked vehicles and inadequate snow removal. A double-parked vehicle on Centre Street or South Street will block the path of the LRV, causing the LRV to become delayed and delaying any vehicles behind the rail car. This type of incident could be minimized using the previously discussed enforcement and parking management. The impacts of inadequate snow plowing or snow removal would have the same type of effect if snow banks along the curb gutter force parked vehicles to encroach on the LRT corridor.

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[16] Morales, Juan M. *Analytical Procedures for Estimating Freeway Traffic Congestion*, ITE Journal, January, 1987.

[17] Pfefer, Ronald C. and Richard A. Raub. *Effects of Urban Roadway Lane Blockage on Capacity*, ITE Journal, January, 1998.

Accidents. The occurrence of accidents along the corridor, which is described under Existing Conditions, will block and delay transit service. The LRVs are much more sensitive to these impacts than buses since the LRVs cannot maneuver around vehicles involved in an accident. Because of their narrow width and high parking demand, Centre or South Street provide limited opportunity for vehicles to pull out of the travelway when an accident occurs.

7.8. Emergency Response Time

The Boston Fire Department operates a fire station on Centre Street and, as such, the corridor is an important emergency response route. The width of the corridor and the level of traffic and parking activity present challenges for emergency response vehicle using Centre Street and South Street. Observations indicate that the current right-of-way on Centre Street is adequate for vehicles in the travel lane to pull close to the parking lane and create sufficient width in the center of the street for a fire truck or ambulance as shown in Figure 15. However, an LRV in the same circumstance will not be able to move off to the side of the road because it operates in a fixed guideway. This could cause some delay to the emergency vehicles response time as it navigates around the LRV. Letters commenting on the proposed service are provided in Appendix B and C from the Police and Fire Departments respectively.

7.9. Effect on Green Line Service

The impacts from the restoration of light rail service to the Arborway corridor upon the Green Line and central subway system was not evaluated as this was beyond the scope of this study. However, restoration of LRT service, particularly in a congested mixed traffic corridor is susceptible to delays due to competing interest on the street including general purpose traffic, double parked vehicle, pedestrians and other disruptions. These delays could adversely impact the ability to maintain desired headway in the central subway system.

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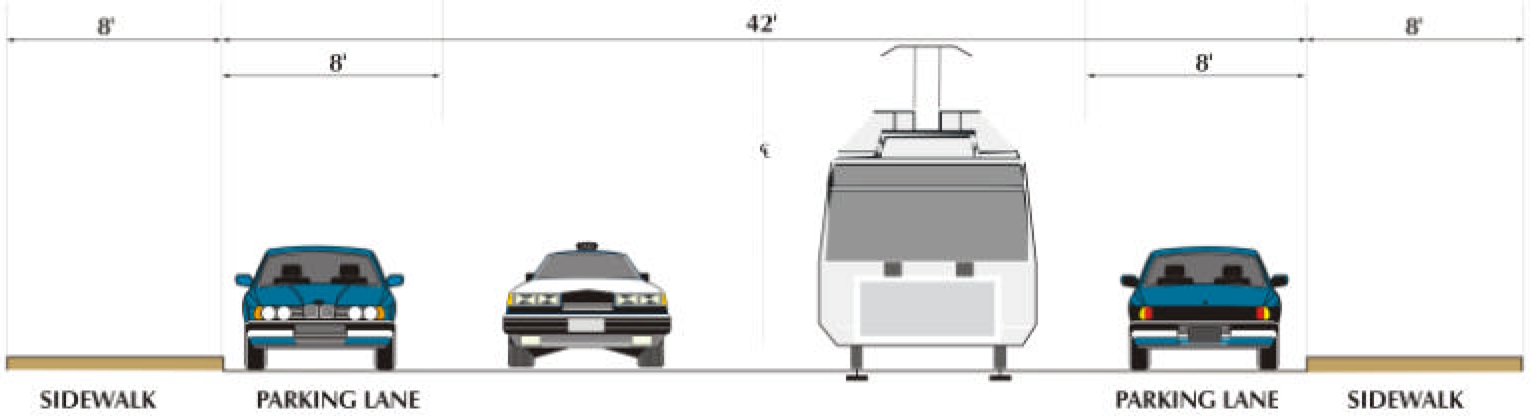
Restoration of Light Rail to the Arborway

Typical Section - Centre Street with Rails



Typical Section - Centre Street without Rails

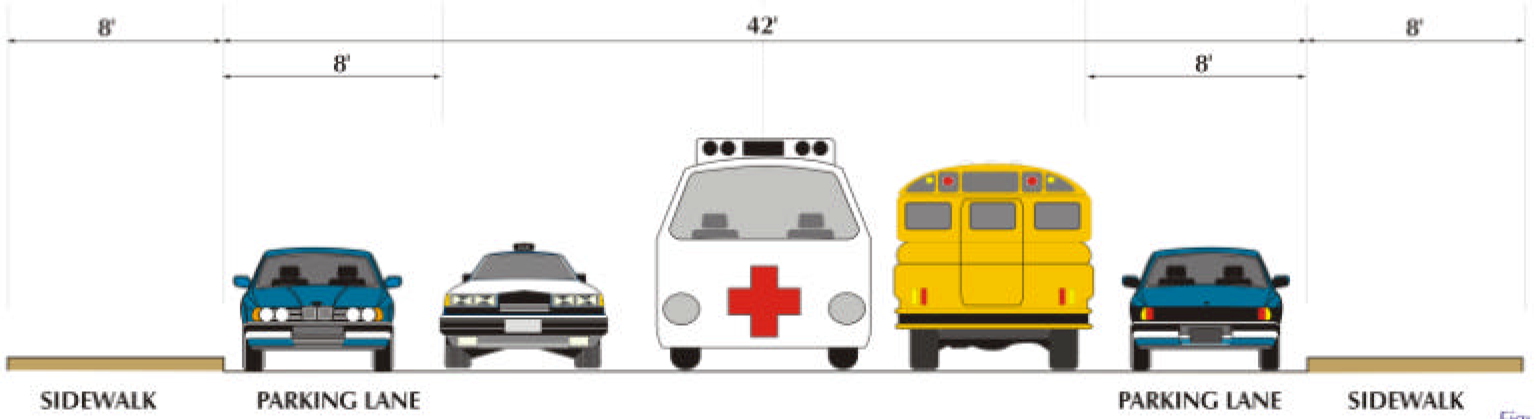
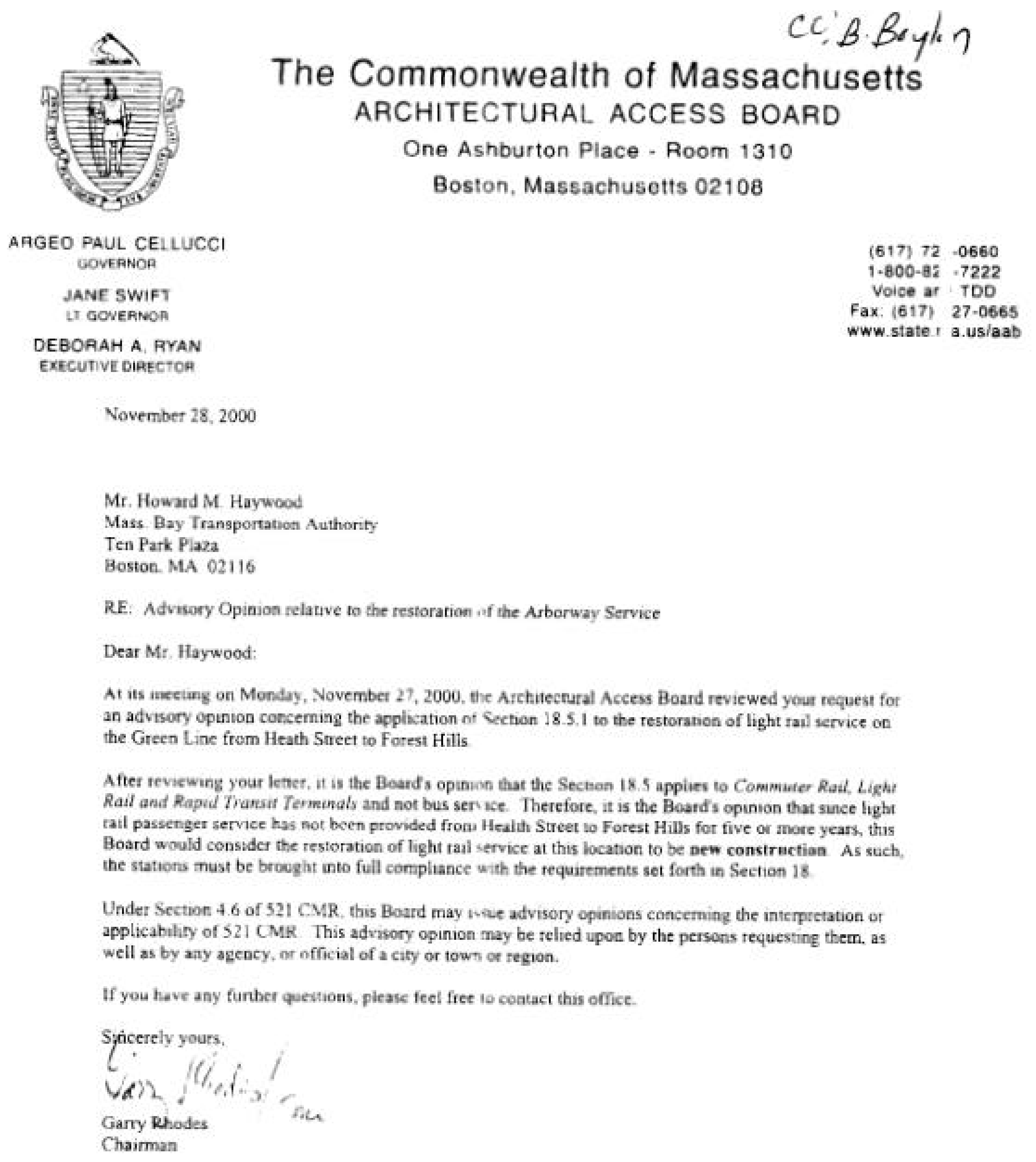


Figure 15

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

APPENDIX

A. Letter from Architectural Access Board
B. Letter from Boston Police Department
C. Letter from Boston Fire Department



CC: B. Boylan

The Commonwealth of Massachusetts
ARCHITECTURAL ACCESS BOARD
One Ashburton Place - Room 1310
Boston, Massachusetts 02108

ARGEO PAUL CELLUCCI
GOVERNOR
JANE SWIFT
LT GOVERNOR
DEBORAH A. RYAN
EXECUTIVE DIRECTOR

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www.state.r a.us/aab

November 28, 2000

Mr. Howard M. Haywood
Mass. Bay Transportation Authority
Ten Park Plaza
Boston, MA 02116

RE: Advisory Opinion relative to the restoration of the Arborway Service

Dear Mr. Haywood:

At its meeting on Monday, November 27, 2000, the Architectural Access Board reviewed your request for an advisory opinion concerning the application of Section 18.5.1 to the restoration of light rail service on the Green Line from Heath Street to Forest Hills.

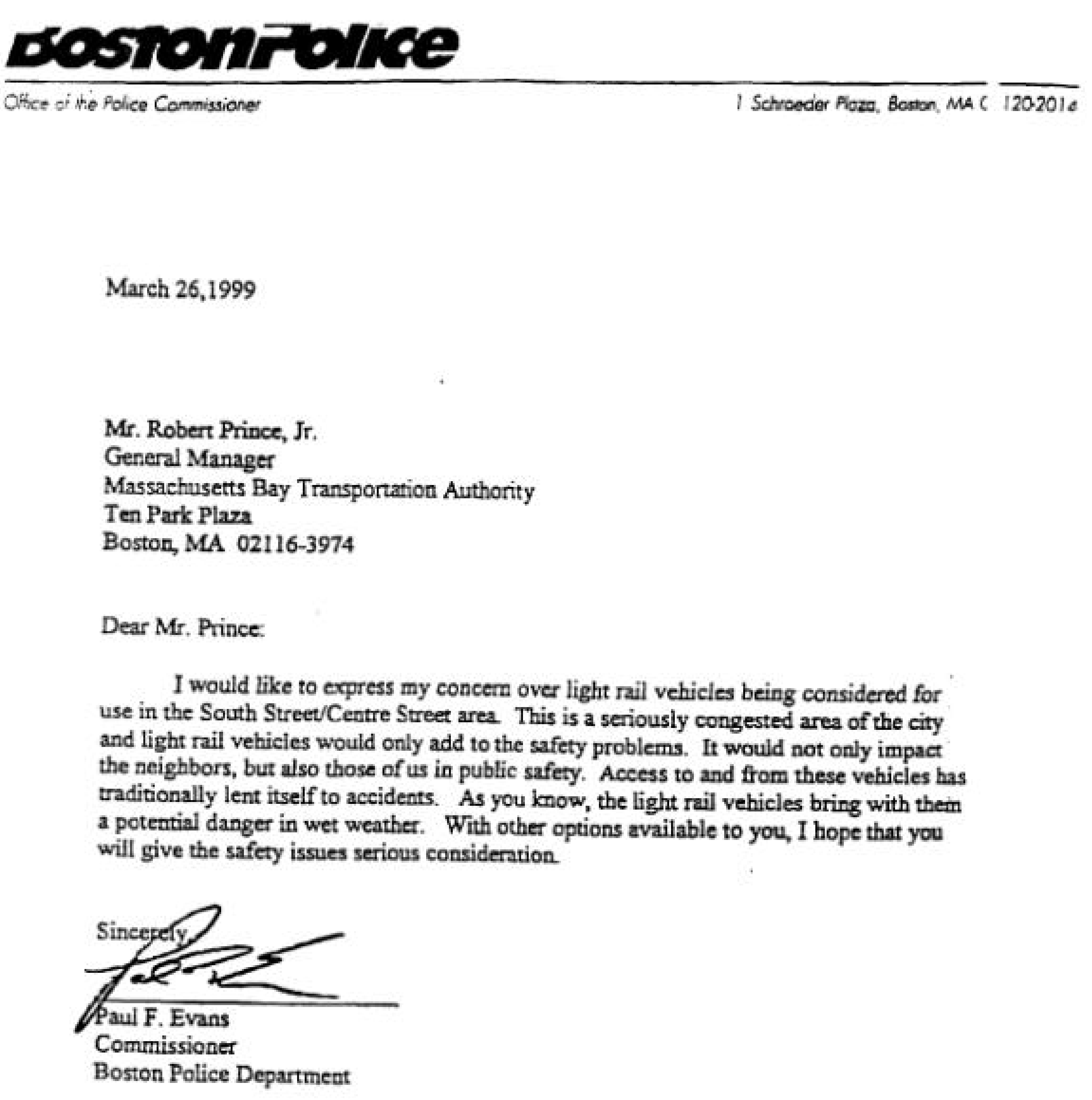
After reviewing your letter, it is the Board's opinion that the Section 18.5 applies to *Commuter Rail, Light Rail and Rapid Transit Terminals* and not bus service. Therefore, it is the Board's opinion that since light rail passenger service has not been provided from Health Street to Forest Hills for five or more years, this Board would consider the restoration of light rail service at this location to be **new construction**. As such, the stations must be brought into full compliance with the requirements set forth in Section 18.

Under Section 4.6 of 521 CMR, this Board may issue advisory opinions concerning the interpretation or applicability of 521 CMR. This advisory opinion may be relied upon by the persons requesting them, as well as by any agency, or official of a city or town or region.

If you have any further questions, please feel free to contact this office.

Sincerely yours,

Garry Rhodes
Chairman



BOSTON POLICE
Office of the Police Commissioner
1 Schroeder Plaza, Boston, MA 0 120-2014

March 26,1999

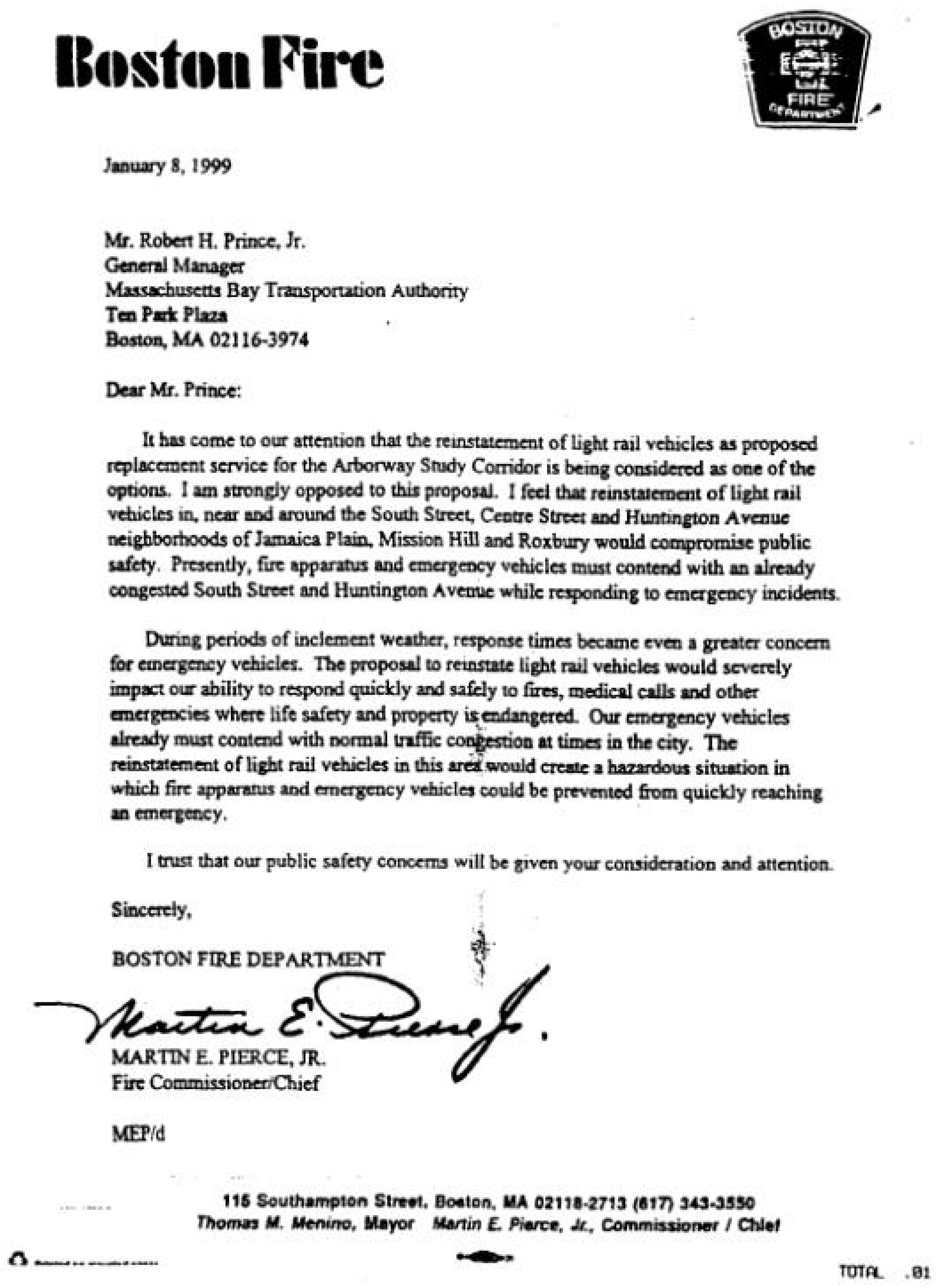
Mr. Robert Prince, Jr.
General Manager
Massachusetts Bay Transportation Authority
Ten Park Plaza
Boston, MA 02116-3974

Dear Mr. Prince:

I would like to express my concern over light rail vehicles being considered for use in the South Street/Centre Street area. This is a seriously congested area of the city and light rail vehicles would only add to the safety problems. It would not only impact the neighbors, but also those of us in public safety. Access to and from these vehicles has traditionally lent itself to accidents. As you know, the light rail vehicles bring with them a potential danger in wet weather. With other options available to you, I hope that you will give the safety issues serious consideration.

Sincerely,

Paul F. Evans
Commissioner
Boston Police Department



Boston Fire

January 8, 1999

Mr. Robert H. Prince, Jr.
General Manager
Massachusetts Bay Transportation Authority
Ten Park Plaza
Boston, MA 02116-3974

Dear Mr. Prince:

It has come to our attention that the reinstatement of light rail vehicles as proposed replacement service for the Arborway Study Corridor is being considered as one of the options. I am strongly opposed to this proposal. I feel that reinstatement of light rail vehicles in, near and around the South Street, Centre Street and Huntington Avenue neighborhoods of Jamaica Plain, Mission Hill and Roxbury would compromise public safety. Presently, fire apparatus and emergency vehicles must contend with an already congested South Street and Huntington Avenue while responding to emergency incidents.

During periods of inclement weather, response times became even a greater concern for emergency vehicles. The proposal to reinstate light rail vehicles would severely impact our ability to respond quickly and safely to fires, medical calls and other emergencies where life safety and property is endangered. Our emergency vehicles already must contend with normal traffic congestion at times in the city. The reinstatement of light rail vehicles in this area would create a hazardous situation in which fire apparatus and emergency vehicles could be prevented from quickly reaching an emergency.

I trust that our public safety concerns will be given your consideration and attention.

Sincerely,

BOSTON FIRE DEPARTMENT

Martin E. Pierce Jr.

MARTIN E. PIERCE, JR.
Fire Commissioner/Chief

MEP/d

115 Southampton Street, Boston, MA 02118-2713 (617) 343-3550
Thomas M. Menino, Mayor   Martin E. Pierce, Jr., Commissioner / Chief

TOTAL .01